

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

no action
OK
DHL

Date: 10/7/78

Project Title: Homeowners and Builders Workshop Program

Project No: A-2227

Project Director: T. McGowan

Sponsor: Georgia Office of Planning & Budget; Energy Resources

Agreement Period: From 8/1/78 Until 12/31/78

Type Agreement: Contract dtd. 8/1/78

Amount: \$24,000

Reports Required: Monthly Financial & Progress Reports; Final Report.

Sponsor Contact Person (s):

Technical Matters

Contractual Matters
(thru OCA)

Mr. Ed Bistany
Georgia Office of Planning & Budget; Energy Resources
270 Washington Street
Atlanta, Georgia 30334

Defense Priority Rating:

Assigned to: Technology & Development (School/Laboratory)

COPIES TO:

Project Director
Division Chief (EES)
School/Laboratory Director
Dean/Director-EES
Accounting Office
Procurement Office
Security Coordinator (OCA) ✓
Reports Coordinator (OCA)

Library, Technical Reports Section
EES Information Office
EES Reports & Procedures
Project File (OCA)
Project Code (GTRI)
Other

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT TERMINATION

Date: May 17, 1979

Project Title: Homeowners and Builders Workshop Program

Project No: A-2227

Project Director: Tom McGowan

Sponsor: Georgia Office of Planning & Budget; Energy Resources

Effective Termination Date: 4/30/79

Clearance of Accounting Charges: 4/30/79

Grant/Contract Closeout Actions Remaining:

- ☒ Final Invoice ~~XXXXXXXXXXXX~~
☐ Final Fiscal Report
☐ Final Report of Inventions
☐ Govt. Property Inventory & Related Certificate
☐ Classified Material Certificate
☒ Other Overrun to be transferred to an EES "E" account

Assigned to: Technology & Development (School/Laboratory)

COPIES TO:

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Library, Technical Reports Section
EES Information Office
Project File (OCA)
Project Code (GTRI)
Other _____



ENGINEERING EXPERIMENT STATION

GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

October 18, 1978

Georgia Office of Energy Resources
270 Washington St., N.W.
Atlanta, Georgia 30339

Re: Monthly Progress Summary Letter
for EES/GIT Research Project A-2227
for period 1 August 1978 through
31 August 1978

Attention; Mr. Ed Bistany

Dear Ed:

This report covers work on the Homebuilders Energy Workshop Program.

Meetings with OER personnel for contract discussion and internal planning meetings with Georgia Tech personnel comprised all work on this project in August.

Sincerely yours,

Thomas F. McGowan
Research Engineer
Project Director

TFMc/gg



ENGINEERING EXPERIMENT STATION

GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

October 19, 1978

Georgia Office of Energy Resources
270 Washington Street, N.W.
Atlanta, Georgia 30334

Subject: Monthly Progress Summary
Letter for EES/GIT
Research Project A-2227
for period 1 September 1978
through 31 September 1978

Attention: Mr. Ed Bistany

Dear Ed:

Organization and planning of this years Homebuilders Energy Workshops commenced in September.

A meeting of the steering committee is set for October 4th at Georgia Tech. A list of those invited is attached, as well as the agenda for the meeting. Dennis Coughlin, an Assistant Research Engineer with Georgia Tech, will be organizing and working on the workshop program. Preliminary discussions with Bob Gaar of OER and Dick Gecoma of the University of Georgia have taken place regarding the new State Energy Codes. Their help will be instrumental in educating builders on new code requirements for energy conservation.

Sincerely yours,

Thomas F. McGowan
Research Engineer
Project Director

TFMc/gg
Attachment

TOPICAL AGENDA

October 4, 1978 Home Builders Energy Workshops

Planning Meeting

- A. Workshop Locations and Dates
- B. Energy Code Additions
 - . Depth of inclusion in this year's workshops
 - . Possible support speakers
 - . Energy code effectiveness
- C. Targeted Audience
 - . Home Builders
 - . Real Estate Agents
 - . Mortgage Bankers
 - . Code Officials
- D. Changes to Last Year's Workshop Content:
 - . Introduction and statement of material to be covered.
 - . The energy crisis - the U.S. energy outlook.
 - . Energy saving devices and materials.
 - . Details of new construction techniques.
 - . Questions and answers.
 - . Break.
 - . Standard construction vs. energy efficient construction for 3 house plans, including economic analysis.
 - . Legislation.
 - . Economic analysis of alternate insulation and building systems.
 - . Questions and answers.
 - . Break.
 - . Sales strategy for selling the energy efficient home.
 - . Summary; energy do's and don't's.
 - . Questions and answers.
- E. Methods for Handling Local Arrangements



ENGINEERING EXPERIMENT STATION

GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

November 2, 1978

Georgia Office of Energy Resources
270 Washington St., N.W.
Atlanta, Georgia 30339

Re: Monthly Progress Summary
Letter for EES/GIT Research
Project A-2227 for period
1 October 1978 through 31
October 1978

Attention: Mr. Ed Bistany

Dear Ed:

This report covers work on the Homebuilders Energy Workshop Program during October.

We held the steering committee meeting as scheduled on October 4th. The meeting went well, and agreement was reached on all items on the agenda. The only major change from last year's program is a heavy emphasis on the Georgia Energy Code and inclusion in the manual of a comparison of the Georgia Code, FHA and other standards which effect construction practices. We are pleased to have the assistance of Bob Gaar, of your office, in this part of the project.

The rough draft of the builders manual is 75% completed, with only the new section on marketing and the code comparison still in process. Project schedules are being met and we recently sent out the full schedule of workshops and locations to members of the steering committee. Bulk mailing to individual builders will take place in November.

Sincerely yours,

Thomas F. McGowan
Research Engineer
Project Director

TFM/cs



ENGINEERING EXPERIMENT STATION

GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

1 December 1978

Georgia Office of Energy Resources
270 Washington Street, N.W.
Atlanta, Georgia 30334

Subject: Monthly Progress Summary
Letter for EES/GIT
Research Project A-2227
for period 1 November 1978
through 30 November 1978

Attention: Mr. Ed Bistany

Dear Ed:

The manual for the workshops was finished and printed this month. Binding and collating should be finished by the first week in December.

The workshop announcement brochure is in the mail to the builders. Only the Atlanta mailing is still in progress. The graphics and visual materials are 80% complete and on schedule. Bob Garr, of your office, produced an excellent simplified guide to the Georgia Energy Code for inclusion in this year's manual. Everything is on schedule and we are looking forward to the first two workshops in Carrollton on December 12th, and Calhoun on December 14th.

Sincerely yours,

Thomas F. McGowan
Research Engineer
Project Director

TFM/jb



ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

February 8, 1979

Georgia Office of Energy Resources
270 Washington Street, N.W.
Atlanta, Georgia 30334

Subject: Monthly Progress Summary
Letter for EES/GIT
Research Project A-2227
for period 1 January 1979
through 31 January 1979

Attention: Mr. Ed Bistany

Dear Ed:

We finished the last six Homebuilder workshops in January. These included Atlanta, Augusta, Savannah, Macon, Columbus, and Saint Mary's/Kingsland. A total of 403 people signed in, and we estimated 425 actually attended the workshops. We have on hand about 300 Homebuilder's Manuals, several hundred copies were sent to Shannon St. John at OER, the rest were distributed at the workshops.

We have contacted Bill Scott at ETV regarding videotaping of the workshop; they do not appear to be interested in the project as they have not shown up at the meetings. Repeated contacts with Bill Scott did not accomplish anything.

As you know, we are planning an eleventh and final workshop for March 13th. John Pruitt from Georgia Power, and representatives from MAACA (Metro Atlanta Airconditioning Contractors Association) have invited us to put on the workshop for their HVAC contractor members.

Sincerely yours,

Thomas F. McGowan
Research Engineer

TFM/jb



ENGINEERING EXPERIMENT STATION

GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

March 1, 1979

Georgia Office of Energy Resources
270 Washington Street, N.W.
Atlanta, Georgia 30334

Subject: Monthly Progress Summary
Letter for EES/GIT Research
Project A-2227 for period
1 February 1979 through
28 February 1979

Attention: Mr. Ed Bistany

Dear Ed:

We have mailed out the course attendance certificates to the majority of the people who attended the workshops. The remainder will go out within a week.

As I mentioned in last month's progress report, we are presenting an extra workshop for heating and air conditioning contractors on March 13th. We are making some minor changes in format for this audience. Approximately 110 manuals remain at Georgia Tech for use at this workshop, the remainder have been shipped to Shannon St. John at OER. We will not mail out completion certificates to the attendees at this final workshop to save cost and time, unless you feel strongly that this is worthwhile.

The table that follows is a breakdown of the people attending the 10 workshops. Of the people signed in, 25% were builders or developers, the business of 19% of the attendees could not be determined. Assuming that the builders and developers were an average portion of this group, their total would be 30% of those in attendance. I think the breakdown of the other groups may interest you, especially the large representation from the utilities. I will go into more detail on the audience in the final report.

Signed In	Completed Questionnaire	Builder	Developers	HVAC	Building Suppliers	Utility	Realtors	Lenders	Other
403	75	70	30	16	65	89	37	19	77

Sincerely yours,

Thomas F. McGowan



ENGINEERING EXPERIMENT STATION

GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

April 3, 1979

Georgia Office of Energy Resources
270 Washington Street, N.W.
Atlanta, Georgia 30334

Subject: Monthly Progress Summary
Letter for EES/GIT Research
Project A-2227 for period
1 March 1979 through
31 March 1979

Attention: Mr. Ed Bistany

Dear Ed:

On March 13 we completed the eleventh and final workshop. As you know, this was a presentation to MAACA, a local heating and air conditioning contractors association. Bill Eckes and Jim Wooly, the association's president and vice president, along with Georgia Power Company organized this meeting. The turnout was excellent, approximately 100 attended. We changed our presentation for this audience, adding more data on HVAC equipment and cost and deleting some information normally aimed at builders.

The last of the course attendance certificates were sent out early this month. The originals and negatives of the Builders Manual have been turned over to Shannon St. John of OER for future reproduction.

I am coordinating the second printing of the workshop manual with Ms. St. John; at your request, we will continue the project for the month of April to facilitate the manuals' reproduction.

All work on contract A-2227 is complete with the exception of the second printing. The final report will be sent in April.

Sincerely yours,

Thomas F. McGowan

Note: Per request: Extension - Cost

TFM/jb



ENGINEERING EXPERIMENT STATION

GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

April 30, 1979

Georgia Office of Energy Resources
270 Washington Street, N.W.
Atlanta, Georgia 30334

Subject: Monthly Progress Summary
Letter for EES/GIT Research
Project A-2227 for period
1 April 1979 through
30 April 1979

ATTN: Mr. Ed Bistany

Dear Ed:

The month of April was spent coordinating the second printing of the workshop manual with the printing office at Georgia Tech. The printing bill is \$1,943.04 for 2,500 copies. Per our conversation, this amount will be added to the present contract. Ms. Shannon St. John has forwarded one box of manuals for our use.

This is the final monthly report for Project A-2227. The project summary and final report is being sent under separate cover.

Sincerely yours,

Thomas F. McGowan

TFM/jb



ENGINEERING EXPERIMENT STATION

GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

April 30, 1979

Office of Energy Resources
270 Washington Street, N.W.
Atlanta, Georgia 30334

Subject: Final Report for EES/GIT
Research Project A-2227
for period 1 August 1978
through 30 April 1979

Attention: Mr. Ed Bistany

Dear Ed:

Total estimated attendance at this year's workshops (total of eleven) is 525, up by 58 from last year. The average attendance is 48 per workshop vs. 47 for last year.

We have examined the list of the people who signed in at the first 10 workshops and listed them in the following table by business type. Note that 19% fall in the undetermined category. It can be assumed that these are equally distributed across the other business headings. Using that basis, builders and developers were 31% of the audience, HVAC installers 5%, suppliers 20%, utility company employees 27%, realtors 11%, lenders 6%.

It appears that we are getting good representation, that in fact the builders are bringing their subcontractors, realtors, etc. It also appears that the builders are relatively well educated in energy conservation and that more needs to be done to educate the other people (lenders, code officials, etc.) involved who may be an impediment in getting an energy conserving house built and sold.

I surveyed the builders to estimate Btu savings brought about by these workshops. The survey instrument is attached. Seventy-five builders and developers completed the survey form at the workshops. I personally called a random sample of 10 of those who completed the form and asked them what changes in construction they would make based on the information they received at the workshop. From their answers, I prepared an estimate of percentage of energy savings which, when multiplied by an average number of houses built per year and average Btu utility use per house, yields a yearly energy savings. This figure is scaled up to account for the 125 estimated builder and developer attendance of the workshops. These figures do not include attendees at the eleventh workshop who were primarily HVAC contractors.

The results are as follows:

1. Estimate of energy savings from 0% to 23%
2. Average energy savings - 11%
3. Energy savings for one year for builders @ 9 houses per year - 1.48×10^{10} Btu/yr

The total in line 3 is 14,800 million Btu. Assuming 28¢ per therm for gas and 4.2¢ per Kw/hr for electricity, this represents a cash savings on utility bills of \$64,000 per year to the owners of the homes built by the builders and developers who attended our meetings. If it is assumed that all those who attended the workshops had an equal influence, the impact would be 3.23 times greater.

Note that the percentage and total Btu savings are lower than last year. The total savings (based on the 3.23 multiplier) is only 18% of last year's estimate. This is to be expected, however, as the law of diminishing returns causes smaller savings for each additional dollar spent.

I think that the above data points to some changes in future programs.

1. The home builders, as a group, appear well educated (at least those who attended); their auxiliaries, the subcontractor, realtor, suppliers, lenders, code officials, etc., may need more education than the builder.
2. There have been examples of existing building codes and their enforcement conflicting with some energy conserving construction techniques. Some interface between the building code officials and programs of this type is needed to straighten out these problems.
3. The builders prefer meetings at night which coincide with their home builder meetings.

Finally, please find attached a copy of the press release from the Georgia Builder magazine. I believe it sums the cooperative atmosphere between Georgia Tech, OER, and the Home Builder Association of Georgia. It has been my pleasure to work on this project with Dennis Coughlin, and Bob Gaar of your office.

Sincerely yours.

Thomas F. McGowan

TFM/jb

Attachment

DISTRIBUTION OF ATTENDEES FOR THE TEN WORKSHOPS

<u>Workshop Location</u>	<u>#Signed in #Completed Questionnaire</u>	<u>#Builders</u>	<u>#Developers</u>	<u>#HVAC</u>	<u>#Building Suppliers</u>	<u>#Utility</u>	<u>#Realtors</u>	<u>#Lenders or Appraisers</u>	<u>#Undetermined</u>
Carrollton	32/20	8	2	1	3	7	3	1	7
Calhoun	15/ 5	4	1	0	6	1	0	3	0
Atlanta - South	21/ 3	1	3	0	6	5	1	0	5
Atlanta - North	26/ 9	8	2	0	2	11	0	1	2
Atlanta - East	87/ 4	17	6	2	9	28	8	7	10
Augusta	31/ 7	9	6	0	3	5	1	3	4
Savannah	45/13	5	3	2	5	10	2	4	14
Macon	64/ 6	8	0	11	9	8	7	0	21
Columbus	50/ 1	6	2	0	12	7	15	0	8
St. Marys/ Kingsland	32/ 7	4	5	0	10	7	0	0	6
	403/75	70	30	16	65	89	37	19	77

REGISTRATION FORM/QUESTIONNAIRE

HOME BUILDERS ENERGY WORKSHOPS

December 1978 - January 1979

Name _____ Company _____ Telephone # _____
Mailing Address _____ Workshop Date & City _____

1. Approximately how many houses did you build in 1978? _____
2. What was the average square footage (living area) of your homes? _____
3. Which of the following energy saving features do you make use of as a standard part of your home construction/design? (please check)

Sill Sealer _____	Heat Pump _____
Soleplate Caulking _____	A/C of EER 9.0 or Higher _____
Wiring Holes Caulked _____	Night Set Back Thermostat _____
Pipe Holes Caulked _____	Furnace Heat Reclaimer _____
Light Colored Roof _____	Furnace Electronic Ignition _____
Continuous Ridge/Soffit Vents _____	Circulating Fireplace _____
Roof Turbines _____	Pack Window Shim Space _____
Gable Louvers _____	Fluorescent Lighting _____
Double Pane Glass _____	Pilotless Stove Ignition _____
Storm Doors _____	Overhang For Shade On South Side _____
Storm Windows _____	Exterior Fireplace Combustion Air _____
Foam Core Doors _____	
Watersaving Shower Heads _____	
Low Flush Toilets _____	

Other (Specify) _____

4. What insulation R values do you normally build into your homes?
Walls _____ Roof _____ Floors _____
5. What percentage savings do you forecast for your homeowners as a result of the energy saving features that you build in? _____ %
6. Did you attend one of last winter's HBEW workshops? Yes _____ No _____
7. How would you recommend improving these workshops? _____

GEORGIA BUILDER



FEBRUARY, 1979
VOL. 6, NO. 8
(USPS 990-600)

OFFICIAL MONTHLY PUBLICATION OF THE HOME BUILDERS ASSOCIATION OF GEORGIA



Ask about 10-Year Power
Construction on this House

**HOW OF GEORGIA
ANNOUNCES SPRING
MARKETING CAMPAIGN**

See Information, Details
on Page 13

FHA-VA

COMMITTEE REPORTS) — *Continued from Page 10*

inspections are *not* sent to the mortgage companies by VA.

• **Marshall-Swift** VA officials stated that Marshall Swift is used only as a guide in VA appraising.

• **Conventionally built homes** A long discussion was held regarding situations where a conventionally built home less than one year home is desired by a customer requesting FHA financing. FHA officials stated that such financing could be handled, but that generally a larger downpayment (10%) is required and the house should be in an approved subdivision, unless the subdivision is already substantially built out. FHA emphasized that it considers each case individually, and it was recommended that FHA be contacted concerning each case.

• **Non-structural certification** FHA officials stated that the mortgagee can certify on small non-structural items. Mr. Jack peppers asked that questions on this subject be directed to him.

• **Specifications used in ordering CRV's**—VA officials reported that all builders should immediately review the specifications used to order VA Certificates of Reasonable Value. If the builder is not building in accordance with the specifications used, change orders will be made for all variations. VA representatives warned that if the builder's specifications stated one type range and he used another without submitting a change order, he builder would be in violation of VA regulations. If back-up inspections reveal that variations are being used, either the builder or the inspector can be suspended.

Chairman Oliver Owens reported that this joint meeting was a very good one, and that quarterly meetings of the committee will be held. He asked that all builder questions with regard to VA or FHA regulations be sent to HBAG Executive Secretary Edna Latimer or to any Committee Representative in the builder's area, and promised a prompt answer to any questions given. He also thanked the FHA/VA officials present at the meeting for their time.



Today is a Good Day
for Buying a Home.

Code Change Proposals Due

The deadline for submitting code change proposals to the Southern Building Code Congress is April 1. A notice has gone out to local association presidents from Codes Chairman William L. Gibbons of Macon for input on requested changes. Richard P. Kuchnicki, Associate Director of Technical Services, NAHB, has also sent out a reminder that any proposed revisions that you would like submitted on behalf of NAHB, you should send it to them as soon as possible

since time is getting short.

This year's code revision committee hearings are scheduled to be held in Memphis sometime in July. A meeting of the Code Review Team will be held prior to the hearings.

This is the time to express your feelings about codes and if you have suggestions to pass along to the Code Review Team, please get this in to the association office in Macon immediately.

THANK YOU FOR ENERGY WORKSHOPS

Following is a quotation from a letter received from the Georgia Tech Engineering Experiment Station, Assistant Research Engineer, Dennis J. Coughlin:

"On January 31st, the last of the scheduled 'Home Builders Energy Workshops' was concluded, the St. Mary's/Kingsland area. The completion of this workshop brought to a close the ten workshops which began in early December and were conducted throughout the state. I would like to take this opportunity to thank you, the State Home Builders Association, and all the local Home Builders Associations in the state for the invaluable help you extended to us in the carrying out of these workshops.

"It is easy to see why the Home Builders Association of Georgia enjoys

such a good reputation. Leadership, cooperation, and planning were noteworthy throughout the programs.

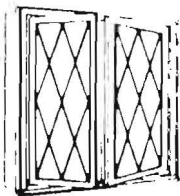

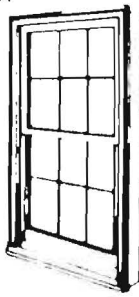
"After having carried out these workshops, there is no question in our minds that builders and others involved in the home construction market are very aware of the importance of energy considerations in the design and construction of new homes, and it is our sincere hope that we have contributed to the ongoing efforts directed at the solution of the energy problems of our state.

"On behalf of Tom McGowan, Project Director, our sponsor, the Georgia Office of Energy Resources, and the Engineering Experiment Station of Georgia Tech, I thank you."

We thank you, Georgia Tech, for these workshops.


Build With The Energy Savers National Insulated Window System

WINDOWS GLAZED STANDARD INSULATING GLASS—CLEAR, GRAY OR BRONZE

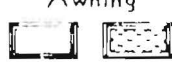




Keep Homes Summer Cool Winter Warm


Casement



Awning



Double Hung



NATIONAL WOODWORKS, INC.

"The Window Unit Center of the Southeast"

BIRMINGHAM
2201 North 29th Ave.
Birmingham, Ala. 35207

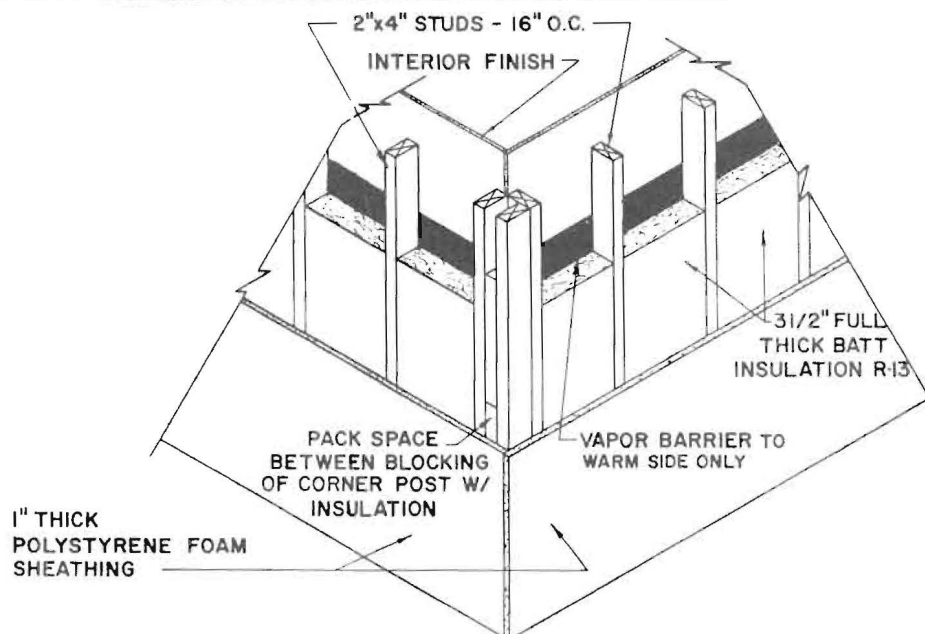
ATLANTA
140 Great Southwest Parkway
Atlanta, Ga. 30331

NASHVILLE
128 G. Alfred Drive
Nashville, Tenn. 37211

Our products sold through building supply dealers.

BUILDING AND MARKETING THE ENERGY CONSERVING HOME IN GEORGIA 1978-1979

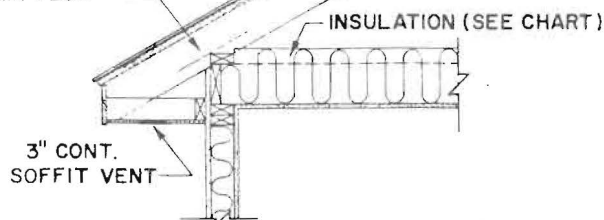
CONVENTIONAL FRAMING



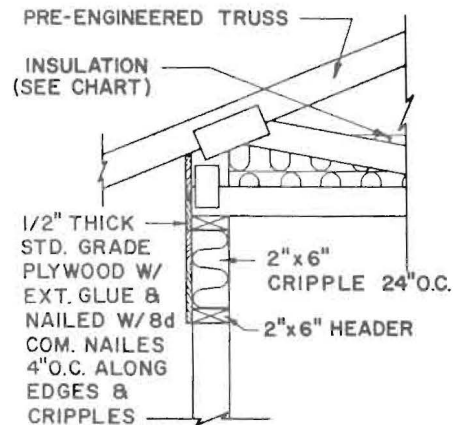
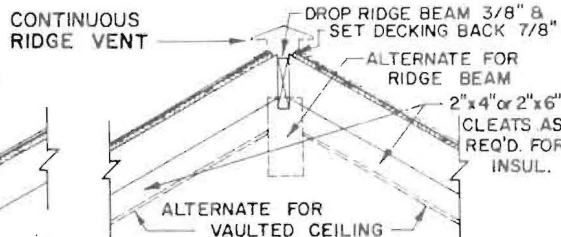
EXTERIOR CORNER & WALL FRAMING

NOTE:
ATTIC VENTILATION REQUIREMENTS DESIGNED FOR COOLING SEASON. THIS WILL BE ADEQUATE TO PREVENT CONDENSATION DURING HEATING SEASON. 1.5 TO 2.0 CFM PER SQ. FT. OF ATTIC FLOOR AREA.

DO NOT RESTRICT AIR FLOW

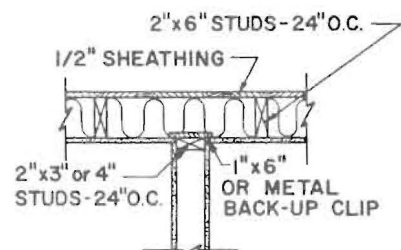


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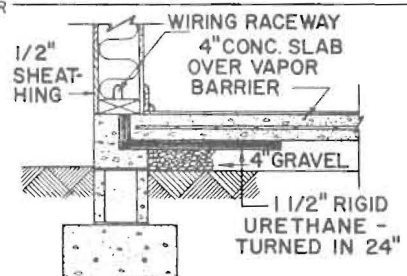


HEADER DETAIL

(MAXIMUM SPAN - 4'-0")



INTERSECTION OF INTERIOR WALL



SLAB FLOOR

BUILDING AND MARKETING THE ENERGY CONSERVING HOME

Produced by Georgia Institute of Technology, Engineering Experiment Station

Thomas F. McGowan, Project Director

Dennis J. Coughlin

H. Byron Gaar

William T. Studstill

Funded by the Georgia Office of Energy Resources

With Assistance from The Home Builders Association of Georgia

First Printing
November 1978

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CHAPTER 1

THE U. S. ENERGY OUTLOOK AND ENERGY COST IN GEORGIA

Energy costs are rising steadily across the nation and in Georgia. The last two severe winters strained the fuel supply system causing plant shutdowns, and the coal strike caused shortages and price hikes. National imports of oil in 1977 and 1978 were about \$50 billion per year. This figure is better understood on a smaller scale. It is equal to \$250 for each person in the U. S. each year. This outflow of money helps create inflation, further decreasing the ability of the homeowner to pay utility bills and house payments.

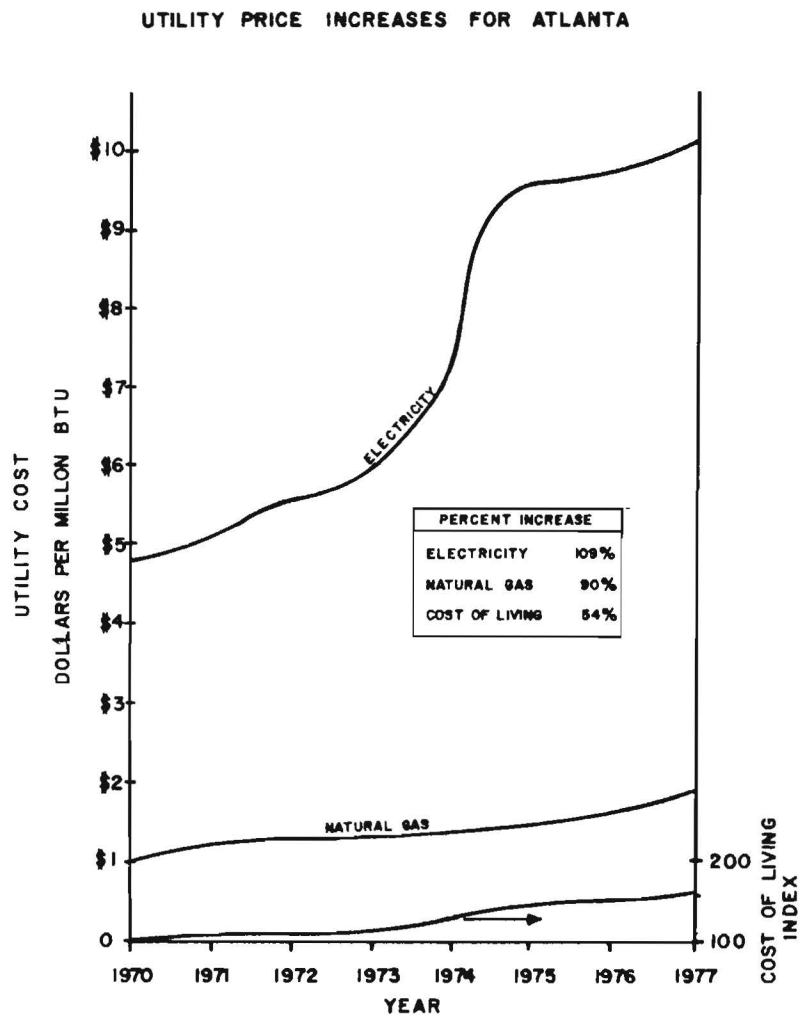
But there is hope. Residential housing can be built which will consume less than half the energy for an additional cost of less than 3%. Houses built now will be standing 50 years or more, saving or wasting energy for that lifetime. Many of the methods used to tighten up a house can only be done during its construction. The cost of retrofitting a house once it's built can be prohibitive.

Conservation is the key. More insulation. Lower infiltration rates. Better glazing and doors. More efficient mechanical systems. Proper orientation and shading. At little extra cost a more comfortable and efficient structure can be built, one the homeowner will be proud of.

Although the supply of fuel has stabilized since the oil embargo and the winter of 1976-77, costs have risen. In the period from 1970 to 1977, residential electricity costs rose an average of 11% per year, natural gas went up 10% per year, and the cost of living rose at 6% per year. It is obvious that these two major energy sources are rising faster than the general inflation rate.

In the last year, natural gas fuel cost adjustment rose more than 4¢ per therm, increasing the cost 17% to nearly 26¢ per therm. Electricity increased from an average of 4¢ to 4.1¢ per kwh, or 2.5%. Price increases for electricity tend to be large, but come infrequently; no large rate hike occurred in the last year. The above increase reflects only an upward trend in fuel cost adjustment caused by peak summer air conditioning loads.

The graph below shows the historic growth in residential energy costs.



CHAPTER 2

DETAILS OF NEW CONSTRUCTION TECHNIQUES

This section covers the following items:

1. Arkansas Plan 2" x 6" Framing System
2. Wall Sheathing with Insulating Rigid Foams for 2" x 4" Framing
3. Thermal Door Systems
4. Window Design
5. Window Heat Loss and Gain
6. Combination Storm Doors for Retrofit
7. Construction Details

It contains basic information on materials and methods used in framing the shell of an energy conserving house. These new construction techniques cut conduction heat loss and gain while keeping material and labor costs to a minimum.

Arkansas Plan 2" x 6" Framing System

Responding to the need for affordable energy conserving housing, an air conditioning engineer, a power company employee, and, years later, a construction analyst created the "Arkansas Plan." This construction method greatly conserves energy and is finding more acceptance by home builders. The original test houses using this construction method were built in Little Rock, Arkansas. Careful analysis of utility bills from these houses showed a dramatic 73.6% savings in energy use for heating and cooling.

The Arkansas Plan produces a conventional looking house, but uses a different framing system that allows more use of insulation. With this system, walls are constructed of 2 x 6 studs on 24" centers, rather than 2 x 4 studs on 16" centers. This cuts down on framing lumber and allows

use of R-19 fiberglass wall insulation. The diagram entitled "Exterior Corner and Wall Framing" shows details on page 10. Note the use of 1 x 6 or plaster back-up clips at the corner to eliminate excess framing and the position of the vapor barrier. The diagram on "Intersection of Interior Wall" shows the same use of a 1 x 6 or metal back-up clips to eliminate framing and allow use of more insulation and less wood in the exterior walls. The "Slab Floor" diagram shows rigid foam perimeter insulation and location of the wiring raceway which keeps wires out of the main wall cavity, allowing it to be completely filled with insulation. The "Header Detail" shows an open header filled with insulation and strengthened with plywood sheathing.

Finally, the "Walls Section" shows an overall view of this framing system, including under-floor insulation and a truss roof which allows installation of extra insulation.

There is less lumber used in this type of construction. Builders who are familiar with the system claim that less labor is involved and there is little if any extra cost over standard construction. The extra cost for insulation is offset by lower cost for smaller heating and cooling equipment.

More information on this construction technique is contained in a booklet from the Owens-Corning Fiberglass Corporation Co., Report No. 1, "Energy Saving Homes, The Arkansas Story."

Wall Sheathing with Insulating Rigid Foams for 2" x 4" Framing

There are 2 basic types of wall sheathing, structural and non-structural. High density fiberboard, plywood, and "Thermoply" are considered structural sheathing. Cross-bracing is not required at the corners of the house with these materials if they are tested and approved for this use.

Rigid Foams ("Thermax", "High R", "Styrofoam", Beadboard) and low density fiberboard are non-structural. They offer much higher insulating

values, (2 to 8 times better than structural sheathing) but must be used with cross-braces on corners of exterior walls.

Structural sheathing is applied with common nails or roofing nails. It must be cut with hand or power saws. Standard sizes are 4' x 8' or 4' x 9' sheets.

Rigid foam sheathing requires roofing nails or other nails with large diameter heads. It can be cut or scored and broken with a razor knife. Standard sizes are 4' x 8', 4' x 9', and 2' x 4' sheets. Some brands have a tongue-and-groove edge; others have a flat edge.

Extra care should be taken when installing rigid foam sheathing to avoid breakage. Any holes in the sheathing should be repaired before the siding is applied. Repairs are made by replacing the damaged section or taping it back in place.

Rigid foam sheathing that has a foil face requires installation of polyethylene vapor barrier between the drywall and wall studs. This prevents moisture from building up in the wall cavity, which can lead to dry rot and peeling of exterior paint. "Thermax," "High R," and "Climate Guard," require a 6-mil poly vapor barrier. Most other foam sheathing that has a foil face backed with cardboard requires a 4-mil poly vapor barrier. Dow "Styrofoam" and white beadboard require only the Kraft paper vapor-barrier on the fiberglass batts.

Thermal Door Systems

Standard pre-hung exterior doors are made of solid wood or a solid core with veneer finish. A new type of door, called a "steel faced foam core door" or just "an insulating door" is rapidly replacing the standard exterior door. These insulated doors have about five times more resistance to heat flow and near zero infiltration (air leakage) rates. Special attention must be paid

when installing these doors.

First, read the instructions. Most manufacturers tape an instruction sheet to the door. Each maker has slightly different installation instructions; be sure to read them carefully.

All steel-faced doors must be shimmed to a proper height so that they will clear the finished floor surface. Standard doors made of wood can be planed if they are too long and scrape on the floor or bind on the rug. You cannot plane a steel-faced door, so allowance must be made during installation so that the door will clear any conceivable floor finish; i.e., plush wall-to-wall carpet, hardwood floor, etc.

The threshold of these doors are adjustable in height to position the threshold snugly against the weatherstrip at the bottom of the door. One common adjustment system is large exposed screws that, when turned, raise and lower the threshold; another uses sliding wedges to change the threshold height. There are other systems on the market; again, check the manufacturer's instructions.

The doors usually are pre-drilled for the entry lock. Many home buyers want the extra protection of a deadbolt lock. If this is the case, the door should be ordered pre-drilled for the entry lock and deadbolt lock to save mistakes and time in the field.

Many manufacturers include two extra long screws with the installation instructions. If these are provided, they should be used to replace screws in the top hinge. Their extra length allows them to penetrate the rough framing behind the finish door frame. This helps strengthen the door system and better supports the higher weight of the insulated door.

Window Design

The window is both hero and villain in energy conservation. Windows admit natural sunlight, fresh air, and ventilation. They also lose heat

during the winter and gain heat during the summer. Obviously, a compromise is needed. Proper window design incorporates the following rules:

1. Minimize the amount of glass area, keeping it just above the minimum code requirements.

2. Eliminate or minimize use of glass on the west side to reduce solar heat gain during the summer.

3. Minimize use of glass on the north side.

4. Maximize use of glass on the south side and use a properly designed overhang to shade the glass during the summer and allow the sun to enter during the winter.

5. Use high quality windows with low air infiltration rates; install storm windows or double glazing.

Large expanses of glass are a thing of the past, unless specially designed on a passive solar collector system on the south side of a house. This type of design must provide for massive construction (concrete slab floor, etc.) to store and release the heat and prevent overheating. A single pane window will lose about 20 times more heat per square foot than a well-insulated wall. It can be said that people who live in glass houses - shouldn't. The cost of heating and cooling them will become prohibitive in the future.

Window Heat Loss and Gain

A. Winter Heat Loss

U values are commonly used to express overall conduction heat loss for windows. A single pane window has a U value of 1.13; add a storm window, and the U value is 0.64, or 44% less heat loss. Double glazing has a U value of 0.71, or 38% less heat loss than single pane, and triple glazing has a U value of 0.42, 63% less heat loss than single pane. The R value of single pane, double pane, single pane plus storm window, and triple glazing are 0.88, 1.41,

1.56, 2.38, respectively. Triple glazing is not economic in Georgia at this time, but may prove feasible in the future, especially on all-electric homes.

B. Summer Heat Gain

Solar heat gain is a large portion of the air conditioning load. It is worth comparing the heat gain of various window configurations, using a single pane, east or west facing window as the basis.

	<u>Percent reduction in window heat gain</u>
Single pane, no shade, facing east or west	0%
Single pane, no shade, facing south	47%
Single pane, no shade, facing north	65%
Single pane, with white roller shades, facing west	24%
Single pane, with full shade, all directions	71%
Double pane, with full shade, all directions	82%

Some conclusions may be drawn from the above:

Unshaded east or west glass produces the highest air conditioning load; west glass is the worst orientation, as the solar gain through the window occurs at the hottest time of the day. White, opaque window shades reflect some sunlight, cutting the heat gain significantly.

Exterior shading (shade screen, awnings, porches, trees) is the most effective way to control the solar heat gain that causes high air conditioning loads. Placing the garage or carport on the west side of the house and eliminating the glass on this side is an effective way to prevent the problem before the house is built.

Combination Storm Doors for Retrofit

Storm doors are not a good choice for new construction. The metal-clad foam core door costs the same as a standard door plus storm door and the metal-clad door is superior in insulating capability. They are useful for retrofit of existing houses. Most better models offer a screen for summer use, with a vertically sliding glass window. Less costly types

require removal of the glass and replacement with the screened insert.

Payback periods and installation are the same as with storm windows.

Construction Details

The following page is W.D. Farmer's guide to energy conserving construction. It covers many of the details listed above and proper installation of new insulation systems.

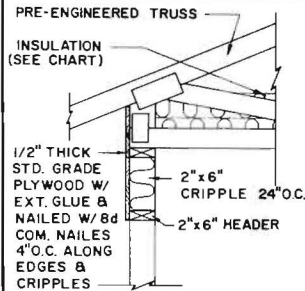
ENERGY CONSERVATION THRU INSULATION

TWO WAYS TO UPGRADE INSULATION

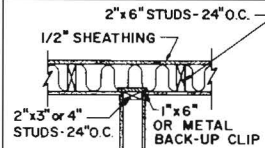
(CHECK ONE ☒)

THE ARKANSAS PLAN

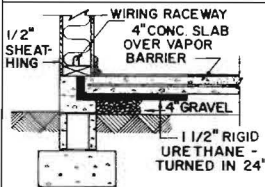
(2"x6" FRAMING SYSTEM) ☐



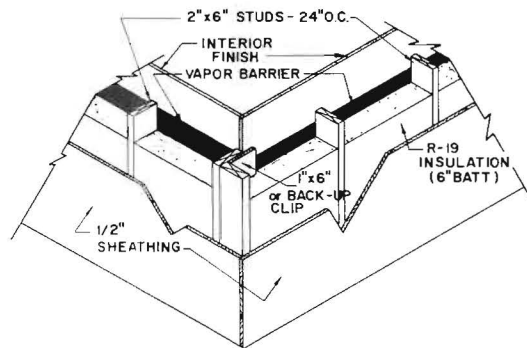
HEADER DETAIL
(MAXIMUM SPAN - 4'-0")



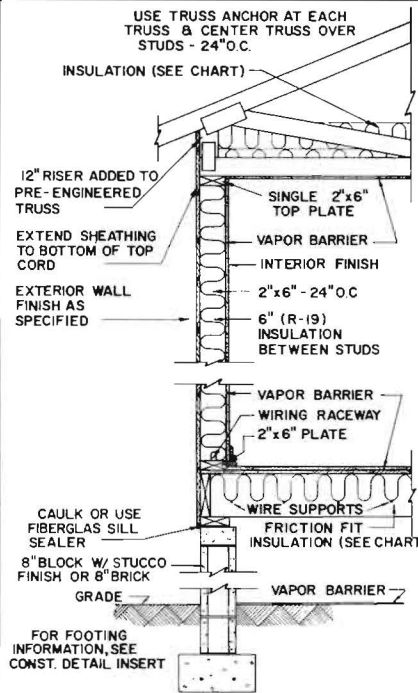
INTERSECTION OF INTERIOR WALL



SLAB FLOOR



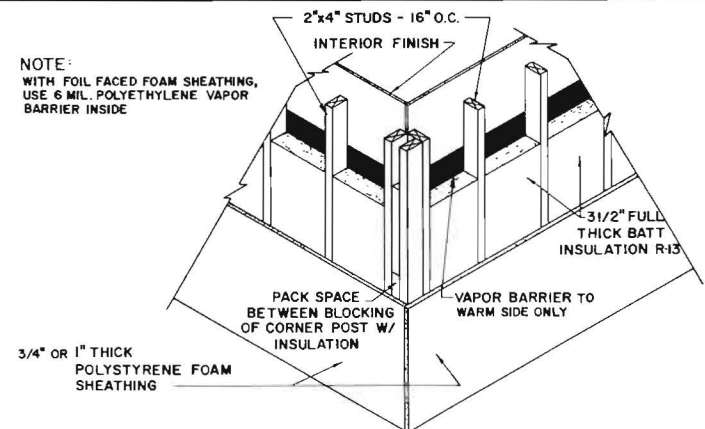
EXTERIOR CORNER & WALL FRAMING



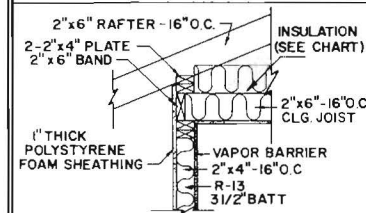
WALL SECTION

CONVENTIONAL FRAMING ☐

NOTE:
WITH FOIL FACED FOAM SHEATHING,
USE 6 MIL. POLYETHYLENE VAPOR
BARRIER INSIDE



EXTERIOR CORNER & WALL FRAMING



RAISED RAFTER DETAIL

*NEW (R-VALUE) INSULATION STANDARDS

*RECOMMENDED BY OWENS-CORNING

REGION	CEILING	WALLS	FLOOR
ZONE #1	38	19	22
ZONE #2	33	19	22
ZONE #3	30	19	19
ZONE #4	26	19	13
ZONE #5	26	13	11
ZONE #6	19	11	11

NOTE : THESE METHODS APPLY TO BRICK VENEER AND/OR FRAME CONSTRUCTION

IN ENERGY EFFICIENT HOUSING, SPECIAL EMPHASIS SHOULD BE PLACED ON MINIMUM INFILTRATION AROUND WINDOWS, DOORS, ELECTRICAL BOXES, PIPES, AND CANTILEVERED AREAS. GLASS AREAS SHOULD BE LIMITED AND DOUBLE GLAZING OR STORM SASH ARE OF GREAT VALUE. ADEQUATE ATTIC VENTILATION SHOULD BE PROVIDED.

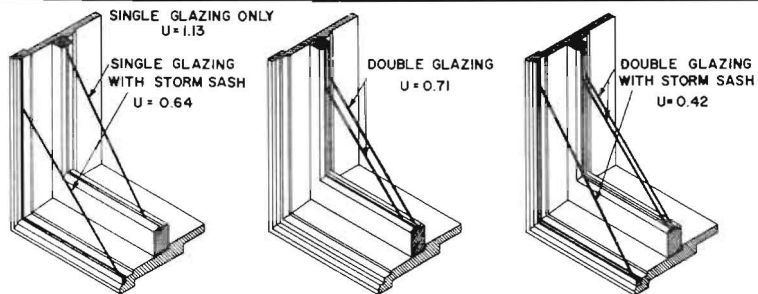
THE DEGREE OF ENERGY EFFICIENCY IS DEPENDENT ON BOTH QUALITY OF WORKMANSHIP AND QUANTITY OF INSULATION



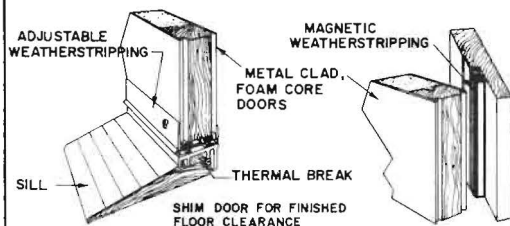
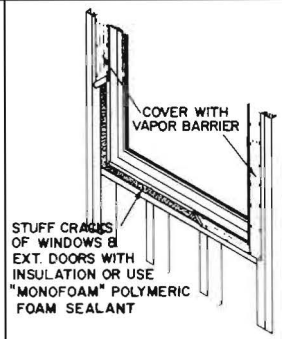
INSULATION DETAILS BY:
W.D. FARMER
RES. SIZE: 11x14. DESIGNED BY: W.D.F.
Home Plans of All Kinds - Stock and Custom Designs
P.O. Box 49883, Atlanta, Georgia 30359
Phone: 404-525-7200
SCALE: NOT TO SCALE PAGE NO 1 of 1

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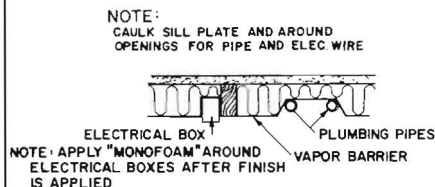
ENERGY CONSERVATION THRU INSULATION



NOTE: THE LOWER THE U, THE HIGHER THE INSULATING VALUE
INCREASE WINDOW GLAZING



THERMAL DOOR SYSTEMS



LIMIT INFILTRATION AROUND DOORS, WINDOWS, ELEC. BOXES, & PIPES.

SPECIFICATIONS FOR ENERGY EFFICIENT HOUSING : (APPLIES TO BRICK VENEER AND/OR FRAME)

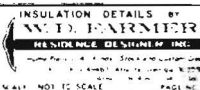
FOUNDATION:

1. WITH UNEXCAVATED AREAS, USE R-13 INSULATION BETWEEN FLOOR JOIST AND 4 MILL POLYETHYLENE VAPOR BARRIER ON GRADE.
2. WITH SLAB FLOOR FOUNDATION OR BASEMENT SLAB ABOVE GRADE, USE 1-1/2" RIGID URETHANE PERIMETER INSULATION.
3. APPLY FIBERGLAS SILL SEALER OR BEAD OF CAULK.

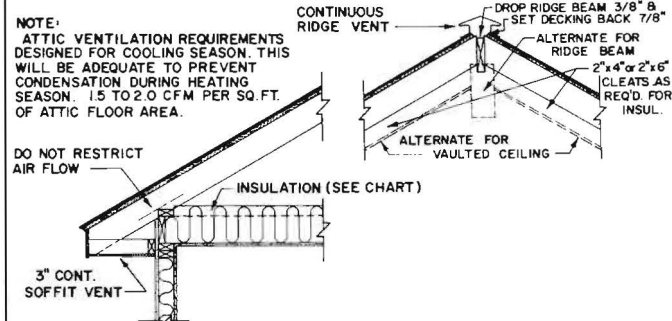
FRAMING:

1. USE 4 MILL POLYETHYLENE VAPOR BARRIER ON WARM SIDE OF WALLS, AND FULL THICK BATT INSULATION BETWEEN 2"x4" EXTERIOR STUD WALLS OR KRAFT FACED INSULATION BETWEEN STUDS. USE 1" THICK POLYSTYRENE FOAM SHEATHING.
2. CHINK AND CAULK AROUND ALL WINDOWS, EXTERIOR DOORS, PIPES, ELECTRICAL OUTLETS, AND CANTILEVERED OVERHANGS. COVER THESE AREAS WITH VAPOR BARRIER.
3. RESTRICT GLASS AREA ON NORTH AND WEST SIDES OF HOUSE AS MUCH AS POSSIBLE. WINDOWS TO BE INSULATING GLASS AND/OR STORM SASH.
4. USE METAL CLAD, FOAM CORE EXTERIOR DOORS WITH MAGNETIC WEATHERSTRIPPING.
5. FOR AMOUNT OF RECOMMENDED INSULATION, SEE CHART, PAGE 1 OF 1, THIS SHEET.
6. USE CONTINUOUS RIDGE AND SOFFIT VENTS AND/OR THERMOSTATICALLY CONTROLLED POWER VENTILATOR FOR ATTIC VENTILATION.

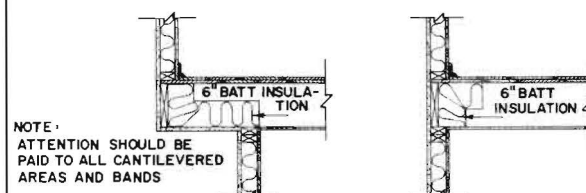
NOTE: SOME OF THE SPECIFICATIONS ON THIS SHEET MAY SHOW GREATER REQUIREMENTS THAN THE CONSTRUCTION PRINTS. IN THAT CASE, THE INFORMATION ON THIS SHEET SHOULD TAKE PRECEDENCE.



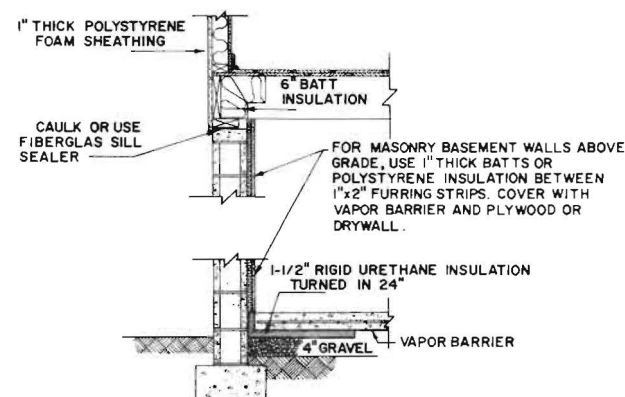
NOTE: IF THESE RECOMMENDATIONS ARE FOLLOWED, IT WILL RESULT IN A 40 TO 45% REDUCTION IN HEAT LOSS AND HEAT GAIN.



ATTIC VENTILATION



SECOND FLOORS



BASEMENT & FIRST FLOOR

CHAPTER 3

HEATING AND VENTILATING SYSTEMS

This chapter covers what the builder and heating contractor should know about energy conservation in heating and cooling systems. We do not cover actual calculation of heat loss and gain; our approach is to explain the correct way to size and select the equipment. The following subjects are contained in this chapter:

1. Heating and Cooling Load Estimation
2. Selecting HVAC Equipment
3. Types of Equipment
4. Sizing Heat Pumps
5. Sizing Air Conditioners
6. Sizing Heating Equipment
7. Zone Control, Separate Systems
8. Sizing Ductwork
9. Duct Design/Installation
10. Controls
11. Ventilation
12. Combustion Air

Heating and Cooling Load Estimation

Probably the most important task to assure high energy efficiency with heating and air conditioning installations is an accurate calculation of the structure's heating and cooling loads. In the past, most installers sized heating and air conditioning equipment by rough block load estimates (for example, 600 square ft/ton). With the current trend toward well-insulated homes and homes constructed with careful attention toward reducing air leakage, rough estimates must be avoided. Inaccurate estimates of heating and cooling loads almost always lead to the selection of oversized heating and air conditioning equipment. Oversized equipment is one of the major factors in energy inefficiency.

Even when going through the calculation of the heating and cooling loads, careful attention should be given to exercising maximum accuracy. Using rough estimates for such things as infiltration and ventilation rates, structural areas, etc., will always lead to an inaccurate heating and cooling load calculation. Quality installation necessitates obtaining accurate information as to structural characteristics and insulation thicknesses and then proceeding with an accurate calculation.

A. Calculation Methods

Within the industry, there are two accepted reference methods used in calculating heating and cooling loads. These are:

1. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).
2. National Environmental Systems Contractors Association - Manual J.

In the past, the ASHRAE guide has been primarily utilized in the calculation of heating and cooling loads for larger systems - commercial, institutional, and industrial applications. For residential applications, the Manual J has been the most used. Due to the more energy efficient building techniques that are currently being used, both of these methods should be utilized as needed. Also, because it is difficult for these reference methods to stay current with the latest energy conservation building techniques, these methods should be modified where a more energy conserving building technique is being employed. Manual J recently added an "Addenda to Table 2, Manual J, 4th Edition" that covers many new insulation systems.

In calculating the cooling load, very accurate data should be used for such things as the solar load and the internal heat load. With the well-insulated home, these loads amount to a large percentage of the total load. Therefore, a rough estimate of the number of people, cooking appliances, square feet of window area for solar load, etc., can make a very big difference in the total calculation.

Another area to give careful attention to in the calculation is the heat loss or heat gain from the ducts. It has been common practice to estimate the duct loss at 10% of the total building load. With the more energy efficient homes, better duct installations are used that will result in less heat loss or gain.

Selecting HVAC Equipment

For maximum efficiency, the heating and cooling equipment must be selected to match as nearly as possible the heating and cooling load calculation. Do not mistrust your calculation and install oversized equipment. Do not allow others to convince you to install oversized

equipment. Oversized equipment can only result in a waste of energy, too much capital cost for the equipment.

There is a general opinion from the contractors who are accustomed to installing equipment in houses with normal insulation that the small units will not be satisfactory in energy conserving houses because of such a small volume of air distributed within the structure. Standards adhered to in the past have dictated or suggested a certain air movement for comfort within a building. When calculations for the better insulated homes indicate a unit one-half the size as is more commonly installed, they raise questions about the possible discomfort and stuffiness with such little amount of air distribution. For this reason, heating contractors have calculated a one-and one-half ton cooling load only to mistrust their calculation and put in a 3 ton air conditioner because of the CFM concern. This should be avoided. Experience with well-insulated homes where small tonnage has been installed shows that comfort conditions are maintained with the smaller CFM's. Remember that air movement and concepts like "CFM per square foot" were created for warm air systems. Older systems that heated houses with steam or hydronic radiators had no CFM passing from room to room. Air circulated at much lower velocities in each room by natural convection. Only enough CFM is needed to properly unload the installed tonnage of the air conditioning system, and to maintain a proper temperature rise from return to supply air for the heating system. Ducts and registers must be downsized to maintain proper velocities into the room for good air distribution.

Types of Equipment

There have been many discussions as to which types of heating and

air conditioning equipment are more efficient. At present utility rates, natural gas heating with electric air conditioning is the lowest cost. Where natural gas is not available, the utility costs for heat pump systems are very competitive with propane gas or oil heating and electric air conditioning. Gas absorption air conditioning with natural gas is competitive with other systems as to fuel cost, but capital investment is so much higher compared to the other systems that it is seldom used. When considering electric units, the heat pump is recommended because of its higher efficiency as compared to resistance heating.

Sizing Heat Pumps

Heat pumps should be sized for the cooling capacity. Efforts should be made to select equipment with cooling capacity as nearly equal as possible to the cooling load calculation. A slight oversize maybe 10%, may be necessary to match particular models of equipment. Equipment that is slightly undersized will operate more efficiently and will provide satisfactory performance if the heat gain calculation has been made with accuracy. Do not undersize by more than 10% however.

It is recommended that auxiliary resistance heater capacity be installed to meet 100% of the heat loss of the structure. These heaters should be wired in incremental stages - approximately 5 KW per stage is the normal practice. Careful attention should be given to controlling the heaters so they are only energized at the lowest possible outdoor temperature. Remember that a heat pump with only the compressor supplying the heat is a very efficient unit, operating at a coefficient of performance of near 2.5 or above around 40° F outdoor temperature. Resistance heaters on the other hand have an efficiency (COP) of 1. Therefore, when the resistance heaters are allowed to be energized at

temperatures where the heat pump cannot handle the heat load or in too many stages, the overall coefficient of performance of the heat pump drops causing the unit to be less efficient.

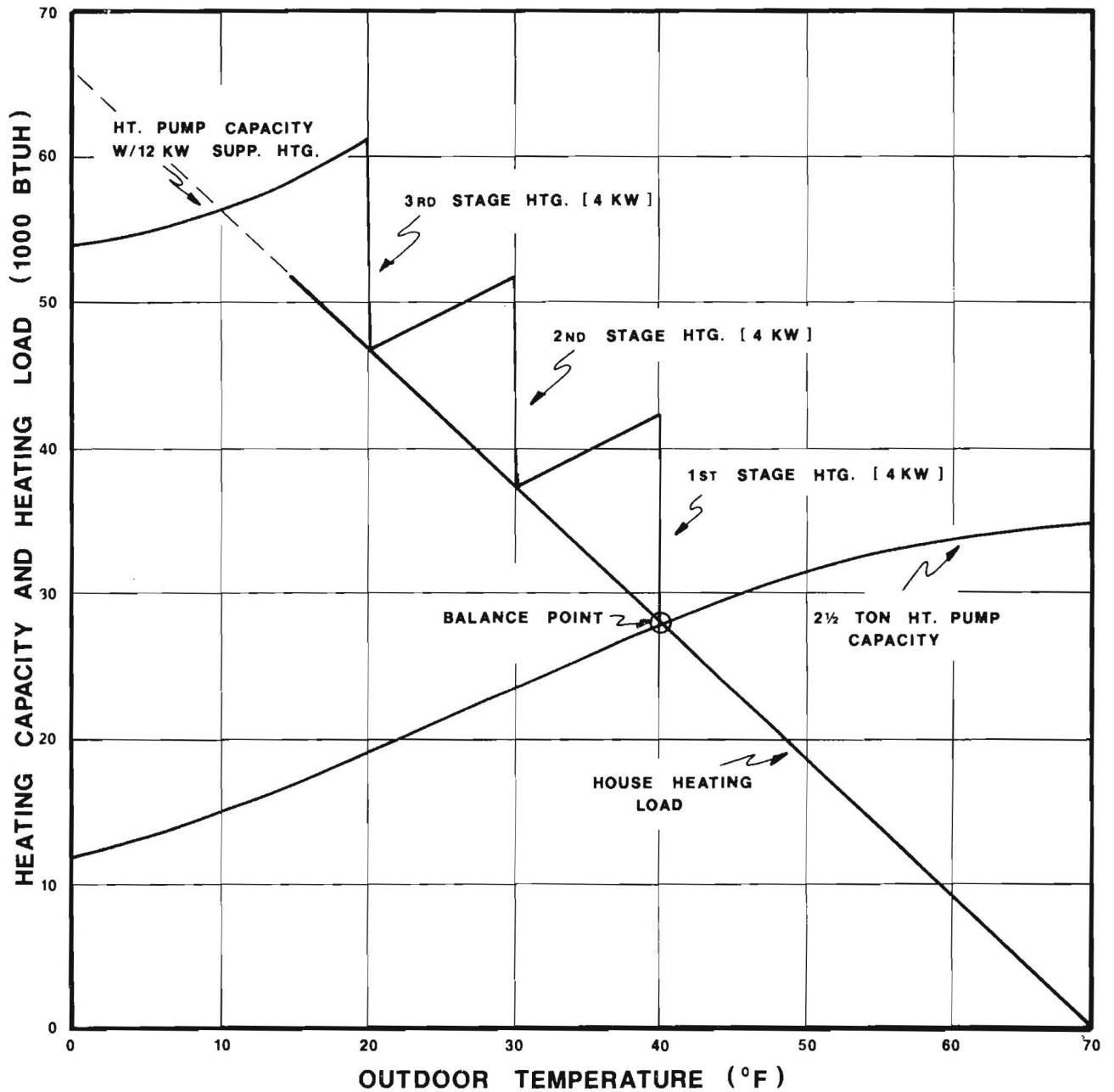
A performance curve should be superimposed on the heat loss curve of the structure. This type of diagram is shown on the following page. This will show at what temperatures resistance heating is needed to supply booster heat to handle the heating load. Let's assume that the compressor can handle the structure heat load down to 40° F outdoor temperature. The first stage of the resistance heaters should be controlled to operate at this 40° F outdoor temperature. This is usually accomplished by using an indoor thermostat with two steps of heating. The number one step controls the heat pump compressor. The second step controls the first stage of auxiliary resistance heating. It is recommended that this first stage also be controlled through an outdoor thermostat set at this 40° setting. The other resistance heater stages are controlled through outdoor thermostats at appropriate settings along with the second stage of the indoor heating thermostat.

A switch should be installed on or near the indoor thermostat to bypass the outdoor thermostats. This allows resistance heaters to be utilized for heating the structure if the compressor is inoperative. It will also allow quick heat recovery within the structure when desired.

Sizing Air Conditioners

Again, air conditioners should be sized so that the capacity is sufficient for the heat gain calculation or cooling load. Oversizing of air conditioning should be avoided. Oversizing an air conditioning system can lead to call-backs. Short cycling due to over-capacity will cause discomfort and lead to high humidity in the house. Longer

Heat Pump Auxiliary Heat Control



cycle times are needed for dehumidification to take place, and the evaporator coil may become blocked with ice under severe conditions. Finally, oversized units will cause high utility bills by less efficient operation.

High EER split systems are available and should be used. An EER of 9.0 or above is generally considered to be an energy conserving air conditioner. Some manufacturers have EER ratings of 10 or more.

Sizing Heating Equipment

As with the air conditioning sizing, heating equipment should be sized to meet the heating load calculation. Oversizing again should be avoided. Many zones can be utilized with electric resistance baseboard heating.

All furnace systems and hot water heaters which burn gas or oil must be adjusted to the correct air/fuel ratio. This is done with a CO₂ test kit. Improper adjustment will cause soot deposits or excess air consumption; both will lower the efficiency of the system.

Zone Control, Separate Systems

In two-story homes and split level homes, it is very difficult to obtain good air distribution in both summer and winter for even-comfort temperature conditions. Separate units are recommended for the upstairs and downstairs. This will provide zone temperature control and result in good efficiency. Separate zones may also be justified where different activities within these zones will result in air conditioning loads at different times of the day or where different temperature settings may be desirable. Zone control in these situations will result in good efficiency; higher settings can be maintained in some areas of little activity, and more comfortable temperature settings can be maintained in

other areas. An example is a zone for the living and dining area and a second zone for the sleeping areas. Separate systems can usually be justified in houses exceeding 2,000 square feet for reasons of economy and control.

Sizing Ductwork

The branch runs should be sized for the heating loads. The thinking for this is that people are more sensitive to the heating comfort than they are to comfort during the cooling season.

Volume dampers should be used in all branch runs. A volume control damper should be used in any main duct that has a splitter (for example, a main duct separating for the upstairs versus the downstairs area). All too frequently installers rely on registers for controlling the volume in balancing the system. This will result in air noise and improper balancing on the system. The volume dampers are very inexpensive and will result in a good quality installation.

Duct Design/Installation

The duct design and installation are very important as to the efficiency of a heating and air conditioning system. Major areas of energy waste include:

1. Improper insulation.
2. Unbalanced system that results in overheating or overcooling certain areas to maintain comfort conditions in others.
3. Inadequate provisions for balancing the system due to changing conditions or changing living habits.
4. Leaking ducts and ducts that are too small resulting in inadequate air distribution and inefficiency of the system.

Careful attention should be given to sealing all duct work and

eliminating any leaks. This is extremely important where there is extensive duct run in unheated areas.

Where ducts are run in unheated areas, both the supply and return ducts should be insulated with two inches of glass fiber insulation. The insulation should have a vapor barrier to the outside (for example, foil-back insulation). The joints and seams should be carefully taped to assure a continuous vapor barrier. Improperly insulated duct and an improper vapor barrier will result in condensation soaking the insulation sharply decreasing its insulating value.

Controls

Controls usually consist of indoor thermostat, outdoor thermostat, time switches, and other related components.

The indoor thermostat should be located near the center of the zone to sense the most representative air temperature in that zone. Careful attention should be given to locating this item away from direct sunlight, heat-producing appliances, behind doors, etc. This control should be located near a main return.

Setback thermostats are gaining in popularity and are a very effective way of reducing energy costs. Experience has shown that these units will pay for themselves in a short time - usually less than two years. This type control utilizes a time switch with day and night thermostat settings. At a preset time at night, the thermostat automatically switches to the night setting. During the heating season, for example, the day setting may be 70°. At bedtime, the thermostat automatically sets back to a night setting of 62° F, and resets to the day setting around 6:00 a.m. the next morning. This technique will yield a substantial energy savings over the year.

Ventilation

With the more energy efficient homes that have better insulation and are constructed to reduce air infiltration to a minimum, some attention should be given to ventilation of the home. The normal ventilation equipment within the home consists of bathroom ventilating fans, range hood ventilating fans, air exhausted for combustion air for furnace, dryer, or other combustion appliances, etc. This air is normally made up by infiltration. However, with the tighter construction, this could cause a problem when exhausting air from the home. One arrangement that might be considered is a fresh air supply duct for the home with a relief damper operated by a pressure differential device. This device would automatically supply make-up air to the home when pressure differentials indicate the need for this air. It would cause ventilation fans to operate properly, but would not induce excessive outside air causing an energy waste. The old method of running an outside air inlet duct into the return system without automatic control of a damper should not be used.

Combustion Air

Ducting combustion air from outside the house to a furnace room in the conditioned space is important. The tighter a house is built, the more difficult it is for a gas, propane, or oil furnace or hot water heater to obtain enough air to burn the fuel. An interior furnace room should have an unvented door with an outside air inlet. It would be better to locate the furnace in the crawlspace or cold storage area rather than the conditioned space to avoid this problem.

In severe cases, the operation of kitchen, bath, and clothes dryer fans can pull stack gases back into the house if the furnace room does not have an outside air duct.

For safety and energy conservation, the furnace room should have an unvented door, and two air inlets should be installed - one near the ceiling and the other near the floor. Both air inlets may be run from an attic - one may be in the ceiling, the other a vertical duct run terminating with a grill near the floor. The size of the openings needed varies with the furnace input rating, whether it's equipped with a draft hood, and where the combustion air is taken in. Check with your local code official for the proper size. NFPA (National Fire Protection Association) Booklet No. 54, pages 23-26, contains diagrams of typical installations. The air inlets must be separated by at least 3-1/2 feet, measured vertically, with the top inlet above the draft board.

CHAPTER 4

STANDARD CONSTRUCTION VS. ENERGY

CONSERVING CONSTRUCTION FOR 3 HOUSE PLANS

Three house plans were selected for thermal and economic analysis. The plans were donated by W.D. Farmer, a residential designer in Atlanta. The house size covers the normal range, 1,200 to 2,200 square feet. Each house has a different heating and air conditioning system. Heating and cooling loads and annual costs are calculated for the three plans using standard and energy conserving construction. The extra cost for the energy conserving features is used in the economic analysis.

The house plans are shown on the following page. The 1200 plan (1200 square feet) is a one story slab-on-grade design. The 1600 plan is one story with a crawl space. The 2200 plan is two stories with a full basement. The heating and air conditioning systems are as follows:

1200: Electric furnace, mechanical air conditioning

1600: Gas furnace, mechanical air conditioning

2200: Heat pump, two systems (zoned)

The standard plan has insulation and equipment found in the majority of present construction. Most of the items meet or exceed minimum property standards.

The energy conserving plan uses added insulation, better infiltration barriers, and glazing to cut heating and cooling loads. The package was assembled with readily available components at a modest extra cost with short payback periods.

The economic analysis, material cost, utility cost, and thermal design are indicative of construction in the Atlanta area. The annual cost for heating and cooling can be approximated for other cities by use of the data found in the appendix.

The following table is a summary of the alternate house systems.

HOUSE PLANS USED IN ENERGY AND ECONOMIC COMPARISON

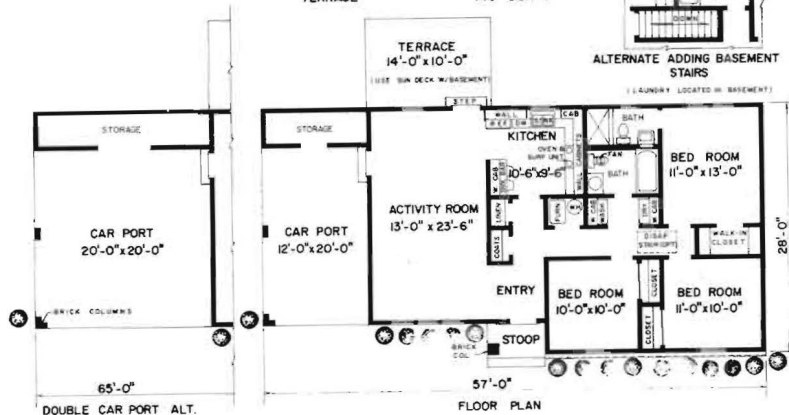


PLAN NO. 1200

HOUSE	1190 SQ. FT.
SINGLE CAR PORT & STORAGE	294 SQ. FT.
DOUBLE CAR PORT & STORAGE	490 SQ. FT.
STOOP	25 SQ. FT.
TERRACE	140 SQ. FT.



ALTERNATE ADDING BASEMENT
STAIRS
(LAUNDRY LOCATED IN BASEMENT)

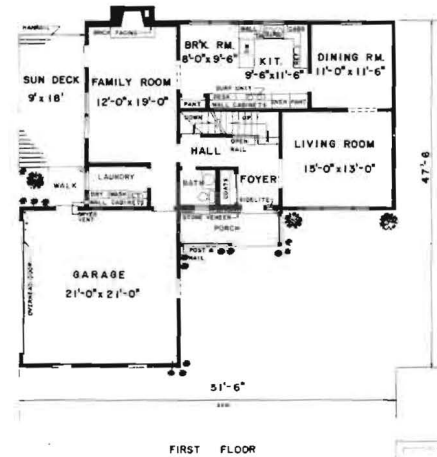


PLAN NO. 1600

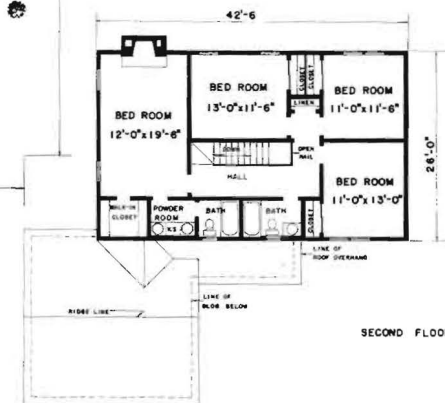


PLAN NO. 2200

FIRST FLOOR	1105 SQ. FT.
SECOND FLOOR	1105 SQ. FT.
TOTAL	2210 SQ. FT.
BASEMENT	1105 SQ. FT.
STOOPS	95 SQ. FT.
DECK	162 SQ. FT.
GARAGE	473 SQ. FT.



FIRST FLOOR



SECOND FLOOR

CONSTRUCTION DETAILS IN STANDARD AND ENERGY

CONSERVING HOUSE PLANS

	<u>Standard</u>	<u>Energy Conserving</u>
Ceiling	R-19	R-26
Walls	R-11	R-13 + R-4 (Rigid Foam)
Floors (1200)	None	1" Rigid Foam
Floors (1600, 2200)	None	R-11
Windows	Single Pane	W/Storm Windows
Doors	Weatherstripped	Insulated Doors
Ducts	2" Duct Insulation	2" Duct Insulation
A/C (1200, 1600)	EER 7.0	EER 9.0
Heat Pump (2200)	Two Systems	Two Systems
Other Features:		
	Standard Thermostat	Set Back Thermostat
	Dark Roof	Light-colored roof
	Roof Louvers	Ridge and Soffit vents
		Sill Sealer
		Extra Caulking (Wet Foam)
		Tight Construction

In the energy conserving version, the ceiling insulation is raised to R-26. The calculations are based on blown fiberglass. The walls have R-13 batts plus 3/4" styrofoam (R-4 wall sheathing) rather than fiberboard sheathing. This was chosen because sheathing thicker than 3/4" requires extension of door and window trim. Storm windows are added to all standard window units. Foam core insulated doors replace standard exterior doors, including french doors. Both plans use 2" duct insulation in attic and basement areas. High efficiency air conditioners (EER 9.0) are used, and a split system heat pump on the 2200 plan. There is little variation in heat pump efficiency for a given manufacturer at present, so no allowance is made for this. Other items in the energy package are a set back type thermostat, light-colored roof, ridge and soffit vents, extra caulking (using wet foam applied by a subcontractor) and tight construction.

The following tables compare the heating and cooling loads and installed equipment size for the alternate plans.

DESIGN HEATING AND COOLING LOAD

HOUSE PLAN	BTUH, Design Load*			
	HEATING		COOLING	
	STD.	EN. CONS.	STD.	EN. CONS.
1200	32,200	15,900	11,200	7,600
1600	48,400	21,300	18,300	10,400
2200	42,400	23,600	21,100	14,600
Average Percent Reduction:	50.3%		35.4%	

*Design load does not include duct loss, latent heat load and equipment efficiency.

INSTALLED EQUIPMENT SIZE

HOUSE PLAN	HEATING		COOLING	
	STD.	EN. CONS.	STD.	EN. CONS.
1200	16KW	11KW	1-1/2 Ton	1 Ton
1600	80M BTUH	40M BTUH	3 Ton	1-1/2 Ton
2200	3-1/2 Ton	2-1/2 Ton	3-1/2 Ton	2-1/2 Ton

The savings are dramatic, the heating load cut in half, cooling load by one third. Equipment size drops correspondingly, using the nearest equipment size which will handle the load. On the 2200 plan, only a 2 ton system is needed for the total load, but the first floor has a higher load and requires a 1-1/2 ton heat pump.

NOTE: Equipment sizing is important! The following is a quote from Ralph J. Johnson, President of the NAHB Research Foundation:

"DO NOT LET AN OVERLY CONSERVATIVE MANUFACTURER, HVAC CONTRACTOR, ARCHITECT OR ENGINEER CONVINCE YOU TO USE OVERSIZED HEATING OR COOLING EQUIPMENT. THIS IS THE CARDINAL ENERGY SIN".

"An oversized heating or cooling unit costs more to purchase, costs more to operate, wastes more energy and produces less comfort".

Heating equipment is available in smaller sizes. Several manufacturers offer one-ton heat pumps, others have 40,000 BTUH input furnaces that can handle several tons of air conditioning.

Finally, we have estimates of annual heating and cooling costs for the standard and energy conserving plans.

ANNUAL HEATING AND COOLING COST AND CONSUMPTION

HOUSE PLAN	HEATING		COOLING	
	STD.	EN. CONS.	STD.	EN. CONS.
1200	\$420 12,000 Kwh	\$130 3,710 Kwh	\$145 3,080 Kwh	\$ 70 1,440 Kwh
1600	\$260 1,000 Therms	\$ 90 340 Therms	\$290 6,160 Kwh	\$110 2,330 Kwh
2200	\$250 7,110 Kwh	\$125 3,570 Kwh	\$300 6,380 Kwh	\$205 4,330 Kwh

We see some surprising savings. Annual heating and cooling cost for the 1200 plan drops from \$565 to \$200 down 65%, the 1600 plan drops from \$550 to \$200 down 64%, and the 2200 plan goes from \$550 annual cost to \$330 down 40%.

Are these savings possible? Yes, houses built under the Arkansas Plan with roughly similar thermal characteristics showed 73.6% savings over MPS construction in actual use. But remember, these savings are

possible only when houses are built to the specification used in the energy conserving plan. Insulation that is missing or improperly installed can't reduce heat loss. Sole plate caulking can't cut infiltration if it's missing. Attention to detail is the mainstay of tight construction.

Now that we have seen the savings, what about the extra cost?

Total extra cost (to the home builder) is listed below. An item by item breakdown is found in the Appendix.

HOUSE PLAN	EXTRA COST FOR ENERGY CONSERVING CONSTRUCTION	
	Total Dollars	Dollars per square foot
1200	\$ 1,004	\$.84
1600	\$ 1,388	\$.87
2200	\$ 1,299	\$.59

Total cost includes ceiling, wall and floor insulation, storm windows, insulated doors, higher efficiency air conditioners, set back thermostat, ridge and soffit vents, sill sealer, and caulking for piping and wiring holes. The reduction in operating costs takes these items into account.

The reduction in heating and cooling loads brings with it a need for smaller heating and cooling equipment. The following table shows the comparative installed HVAC equipment cost.

HVAC EQUIPMENT COST

<u>House Plan</u>	<u>Standard</u>	<u>En. Cons. Plan</u>	<u>Savings</u>
1200	\$1,650	\$1,450	\$200
1600	\$2,200	\$1,720	\$480
220	\$3,960	\$3,360	\$600

The savings on installed equipment cost for the 1200, 1600 and 2200 plans are 12%, 22%, and 15%, respectively. These reductions are primarily from reduced tonnage on the air conditioner and heat pump. Smaller savings are from reduced duct and flue size and associated insulation cost. It is obvious that cutting a load in half cannot cut the installed cost in half.

The extra cost of installing a higher efficiency air conditioner (EER 9.0 instead of 7.0) and the set back type thermostat is included in the previous table entitled "Extra Cost for Energy Conserving Construction". These additions would bring the HVAC cost closer to that of standard construction. Equipment savings are realized only when the HVAC contractor properly sizes the equipment. Using the same rule of thumb just won't do. Installing the 'normal' air conditioner tonnage in a house with a glass wall on the west side will find the system short on capacity. In the same way, installing the 'normal' tonnage on a house without windows on the west side, with tight construction, etc. will find the unit oversized. The same is true of heating systems. A new 'rule of thumb' will generate itself with experience on energy conserving homes.

A final table shows the cost of the energy conserving features and the HVAC equipment savings. Two figures are included for dollars per square foot. The first is the cost to the builder. The second includes overhead and profit, and is the cost to the home buyer.

The extra cost per square foot of house is less than 3% of the selling price of the house. The payback period of the energy package is 3-4 years. These are numbers that any builder and buyer can live with.

SUMMARY TABLE, COST DIFFERENCE OF STANDARD
AND ENERGY CONSERVING HOUSE PLANS

HOUSE PLAN	EXTRA COST OF MATERIAL	EQUIPMENT SAVINGS	NET EXTRA COST	COST TO BUILDER \$ PER SQ. FOOT	COST TO HOMEBUYER \$ PER SQ. FOOT	ANNUAL SAVINGS	PAYBACK PERIOD - YEARS
1200	\$1004	\$200	\$804	\$.67	\$.87	\$365	3
1600	\$1338	\$480	\$910	\$.57	\$.74	\$350	3
2200	\$1299	\$600	\$699	\$.32	\$.42	\$220	4

CHAPTER 5

ECONOMIC ANALYSIS OF INSULATION, BUILDING SYSTEMS AND EQUIPMENT

This chapter quantifies the cost factors involved in energy conserving construction and the payback periods from their use. We are in the age of energy conservation - it is cheaper to pay for an energy saving house through mortgage payments than to pay rising utility costs.

Four areas are covered;

1. Economics of Insulation and Building Systems
2. Energy Conserving Equipment
3. Wood Stoves and Fireplaces
4. Solar Hot Water Heaters

Economics of Insulation and Building Systems

The payback periods shown are found by dividing the extra installed cost of an item by the first year savings. This does not take into account rising fuel cost, inflation, interest rates, etc. However, it is the most foolproof and uncomplicated way of judging the relative merits of energy conserving items.

Due to rising fuel costs, the payback periods will undoubtedly be shorter. In addition, the lower first cost of the smaller heating and air conditioning system will also produce a faster payback.

All calculations are based on standard construction at prevailing energy costs for Atlanta. The table on the next page lists the more energy conserving option followed by a slash and the item it is compared to. Values listed are from the Georgia Power Company and Atlanta Gaslight Company. Figures not available from these sources were calculated using "Manual J" and published test data.

Comparison of Insulation and Building Systems

<u>Item</u>	<u>PAYBACK PERIOD IN YEARS</u>		
	<u>Gas & A/C</u>	<u>All Electric</u>	<u>Heat Pump</u>
<u>Ceilings</u>			
R-30/R-11 Batt	7	3	6
R-26/R-19 Blown	7	4	6
<u>Cathedral Ceiling</u>			
R-13 + 1" Foam, vented/ R-19, Full Thickness, unvented	45	45	45
R-19, 2 x 8, vented/ R-19, 2 x 6, unvented	16	16	16
(See note on cathedral ceilings)			
<u>Walls</u>			
R-13 + 3/4" Foam/R-11	4	2	3
R-13/R-11 (See note on walls)	2	1	2
<u>Floors</u>			
Over basement R-11/R-0	6	3	4
Over crawl space R-11/R-0	2	1	2
<u>Windows</u>			
Storm/No Storm	12	5	9
<u>Doors</u>			
Insulated/Wood	2	1	2

Note on Cathedral Ceilings:

The payback period of 45 and 16 years for two of the ceiling systems listed are the same for all three heating and cooling systems. The R factor is essentially the same, yielding the same heating bill. Only the air conditioning load changes due to extra ventilation.

The first option with a 45-year payback is for R-19, 6" fiberglass sandwiched between roof deck and drywall ceiling on 2 x 6 rafters with no ventilation. The energy conserving option uses 2 x 6 rafters with 3-1/2", R-13 fiberglass, plus 1" rigid foam under the drywall and ridge and soffit vents.

The second option is R-19 fiberglass sandwiched between roof deck and ceiling on 2 x 6 rafters. The energy conserving option is R-19 fiberglass with 2 x 8 rafters and ventilated air space over the fiberglass with ridge and soffit vents.

If the ceiling has room for more than 6" batts (while maintaining the ventilation space) the additional fiberglass would be the most economical improvement. The air space is desirable and may be necessary to pass code. The scissors truss is an expensive but good solution in some cases.

It is painfully obvious from the long payback period that cathedral ceilings are a difficult problem. Substitution of rigid foam is a high cost solution. Perhaps the best solution is to limit them to smaller rooms or eliminate them altogether.

Notes on walls:

The savings shown for the R-13 + 3/4" rigid foam construction contains a factor for reduced infiltration. The calculation assumes the foam sheathing reduces infiltration by 0.2 air changes per hour, yielding twice the savings normally attributed to the additional R factor.

Energy Conserving Equipment

<u>Item</u>	<u>Extra Installed Cost</u>	<u>Payback Period, Years</u>
Water Saving Shower Head	\$ 10	1
Water Saving Aerators	\$ 3	1
Low Flush Toilet	None	Save \$15/year
Pilotless Ignition on Furnace	\$100	5
Pilotless Ignition on Range	\$ 75	11
Water Pipe Insulation, First Foot of Hot & Cold Water Pipe	\$ 10	6
Set Back Type Thermostat	\$ 85	3
Humidifier	\$100	See Note
Power Roof Vent	\$ 75	See Note
Ridge and Soffit Vents	\$ 90	10
Heat Reclaimer for Air Conditioner	\$550	See Note
Fluorescent Light	\$ 15	2

Notes on Energy Conserving Equipment:

Water Saving Shower Head: Cuts flow rate to 3 gpm; 50% reduction in water needs for showering.

Water Saving Aerators: Cuts water flow on sinks to 2 gpm.

Low Flush Toilet: Cuts water use per flush from 5 to 7 gallons to 3 to 3-1/2 gallons. Cuts water bill by 15%.

Water Pipe Insulation: Insulating the first 1 and 2 feet of the hot and cold water lines and vent line from the hot water heater can cut these standby losses by 50%.

Pilotless Ignition on Range: Reduction in a gas bill, \$7/month. This item is usually available only on top-of-the-line models.

Set-back Type Thermostat: Reduction in heating bills with 5° night set-back, 11%. Not advisable for heat pump operation.

Humidifiers: Humidifiers can raise comfort levels in a house. However, they do little to save energy, and may even cause higher heating bills. While a 1° to 2° decreased thermostat setting is possible because of higher humidity, yielding fuel savings, 1,000 btu's are needed to evaporate each pound of water added to the house. It costs 20¢ to 80¢ per day to supply this needed heat if a 13 gpd humidifier is running at full capacity.

In a tightly constructed house with low infiltration rates, the water vapor supplied by cooking, washing, and breathing should be enough to keep humidity at a comfortable level without a humidifier.

Attic Power Roof Vent: Extra cost over roof louvers, \$75. Payback period with R-19 or better insulation, fan power consumption may meet or exceed air conditioning savings, fan may never pay for itself. Reduction in ceiling air conditioning load, 25%. Seasonal power consumption, \$12.

Attic Ventilation Note: While attic ventilation in excess of minimum property standards will cut the air conditioning load, the effect is small with large amounts of attic insulation. The continuous ridge and soffit vent is preferred to the power roof vent because of no maintenance, noise, or power consumption.

Ridge and Soffit Vents: Reduction in ceiling air conditioning load, 25%.

Heat Reclaimer for Air Conditioner: These units are composed of a heat exchanger and water pump. They extract heat from the air conditioner and reject it to a pre-heating storage tank for domestic hot water use. They provide hot water and offer a 5 to 10% reduced cost for air conditioning. Problems have been experienced with heat exchanger fouling where drinking water has a high mineral content. Best used where more than 6 months of air conditioning is needed or on all electric houses. Approximate payback: 5 years all electric, 14 years with gas/electric.

Fluorescent lights: These produce about 4 times the light per watt of an incandescent bulb. Lower air conditioning costs, and less frequent and therefore lower replacement costs. Best used in bath and kitchen.

Wood Stoves and Fireplaces

Wood is a renewable fuel which is available today. The fireplace is a familiar extra in many homes being built presently. In the future, more people may choose a wood stove. Why? It's a matter of efficiency. While a fireplace is esthetically pleasing, it is very inefficient. Many

homeowners want to reduce their fuel bills by burning wood, but find little savings possible by using a fireplace. Wood stoves produce much more heat for a given amount of wood. Several companies offer stoves which can be left open to allow viewing of the fire, giving a fireplace effect, or closed for maximum heat output. Below is a list of approximate efficiencies of wood burning equipment.

	<u>Approximate Efficiency</u>
Fireplace	10%
Circulating Fireplace	25%
Wood Stove	40%
Airtight Wood Stove	60%
Central Wood Furnace	65%

These figures on efficiency show how superior a wood stove is to a fireplace. An airtight wood stove requires only 1/6 as much wood as a fireplace to do the same heating job. A circulating fireplace which has a steel liner and circulates warm air to the room is one improvement over the standard masonry type. The addition of glass doors and use of exterior combustion air also improve fireplace efficiency. All fireplaces should have a tight fitting damper to control the fire and prevent air infiltration when not in use. Fireplaces and woodstoves equipped with electric fans are not recommended. When heat is needed most (when electric power is out) they cannot operate and frequently burn out from the resulting high temperatures.

Wood stoves have greater efficiency, but they offer other features as well. A radiant stove can warm you up quickly when you come in from

the cold. You can change the amount of heat you receive by varying the distance between yourself and a radiant stove. A convective wood stove has a decorative sheetmetal cabinet. This offers more safety, especially for small children, as the metal cabinet is much cooler than the firebox wall. Convective heaters pull cold air from the floor; the air is warmed by the stove and rises out the top of the cabinet.

Some airtight stoves have a built-in mechanical thermostat that senses the room temperature and controls the intake air accordingly. Others have an inlet damper that can accurately adjust the intake air to control the fire.

Central wood burning furnaces are available to heat an entire house. Many of them can be purchased with oil or gas burners to take over when the wood is used up. Smaller models can be spliced into an existing central heating system.

All wood burning appliances must be properly vented. A Class "A" flue is required, equivalent to that required for a fireplace. If manufactured chimneys are installed, the double-wall insulated type is preferred for exterior wall installation. A double-wall chimney stays hotter and causes less condensation and creosote formation than a triple-wall chimney.

The cost of wood stove installation varies widely with stove quality and installation. A ballpark figure for a top quality stove, Class "A" factory-built chimney and simple hearth should run no more than \$700 installed, less than half the cost of a basic fireplace. Wood burning multifuel (gas or oil backup) furnaces range from under a \$1,000 to \$2,500. Their weight (up to 1400 lbs) and more complicated control

systems will make installation costs higher than for standard furnaces.

Georgia Tech and the Georgia Forestry Commission have produced a series of information brochures on all aspects of wood fuel use for houses; contact your local Forestry Commission office for further information.

Solar Hot Water Heaters

There is a wide range of solar development going on from crop drying to orbiting solar electric space stations, but the most down-to-earth application is heating of domestic hot water. Solar hot water heaters are being installed on houses in growing numbers. While these solar water heaters are being installed on only 1% or so of new houses in Georgia at present, some forecasters think that 50% of the new home market will have them by 1985. In short, the market is very limited at present, but will increase in the years ahead. The competitive mechanical contractor will be called upon to install and service the systems. Recent tax breaks (a 25% rebate) will increase demand for the systems.

A typical domestic solar hot water heater system consists of the following basic parts:

1. Solar Collector
2. Storage Tank
3. Pump
4. Controls
5. Plumbing and Wiring

The absorber plate is a flat metal plate, painted black, through which water is circulated. Glass covers allow sunlight to shine on the plate, warming it. The back of the collector plate is insulated to reduce heat

loss. The sides and bottom of the collector are enclosed, usually in a sheetmetal pan. The glass (or plastic) covers, absorber plate, insulation and pan when assembled, are called the solar collector. The collector is installed, usually on a roof, facing south, on tilt angle equal to the latitude for year-round hot water heating. When in operation, cool water is circulated through the passages in the collector plate and is warmed about 10° F by the heat of the sun. Collector size varies: a typical collector has about 30 square feet of surface area, and one or two collectors are used to heat water for an average family. Flow rates are about one gallon per hour per square foot of collector area.

The warm water is piped to the hot water storage tank. Most systems use an antifreeze solution and a heat exchanger in the storage tank. The heat exchanger is usually a coiled pipe inside the tank. It prevents the water in the tank from mixing with the antifreeze solution. When hot water is called for, it leaves the storage tank and enters a standard hot water heater. This is the auxiliary or back-up heater which takes over during cloudy weather or periods of high usage.

A small recirculating pump is used to move the antifreeze solution through the system. The pump size is usually about 1/20 hp.

The main control is a differential temperature switch. A temperature sensor is placed on the collector and storage tank. When the collector temperature reaches about 10° F more than the tank temperature, the pump switches on to collect the heated water.

Plumbing is usually copper tubing with soldered fittings. Wiring consists of line voltage wiring of the pump and control plus low voltage wires to the temperature sensors.

This is a general explanation of an active solar domestic hot water heating system. Many small variations exist in materials and equipment and cost. At present, installed cost for these systems range from \$1,000 to \$2,500 for heating domestic hot water. Payback periods range from 5 to 7 years for electric water heating to 12 to 16 years for natural gas heat. These economics will improve with rising utility prices and cost reduction in collector systems.

CHAPTER 6

ENERGY CODE REQUIREMENTS FOR RESIDENTIAL CONSTRUCTION

A new energy code is in effect in the State of Georgia that sets minimum standards for energy conservation in single and multi-family residential housing. This is a minimum code, and most builders already meet or exceed its standards. This code went into effect on July 16, 1978, and all present and future construction is governed by it. The code is officially called the "Georgia State Code for Energy Conservation in New Construction" (Legislative Act 1470, 1978); it is available from Mr. Leslie Zsuffa, State Building Administrative Board, 32 Peachtree Street, N.W., Atlanta, Georgia 30303. The cost of the code is \$6, plus \$1.50 for the "Applications Manual."

The Home Builders Association of Georgia has taken a neutral stand on the code. The major provisions of the Code are equal to or less stringent than the FHA standards that H.B.A.G. has adopted as a minimum standard.

For residential construction it calls for minimum insulation in walls, ceilings, floors, and around slab-on-grade. The code also requires tight-fitting windows and doors, weatherstripping, and caulking of cracks where air infiltration might occur.

The code is unique in that it allows the builder three methods of compliance:

1. Acceptable practice
2. Component performance
3. Alternative design

The acceptable practice method is the simplest to use and involves very

(Continued on page 47)



COMPARISON OF ENERGY CODES FOR NORTH GEORGIA⁴

Insulation Required for Residential Construction

	Georgia Code	FHA ² HUD	Farmers ³ Home Administration
Ceiling	R-19	R-19	R-30
Cathedral Ceiling	R-10	R-19	----
Walls	R-11 R-19 ¹	R-11	R-16
Floors over crawlspace	R-6	R-7	R-16
Slab-on-grade	R-4, R-6 if heated	R-2.5, R-4.4 if heated	1" thick, 24" wide perimeter insulation
Windows	---	---	Storm or Double Pane
Doors	Weatherstripped	Solid Core, Weatherstripped	Insulated Door, or Storm Door

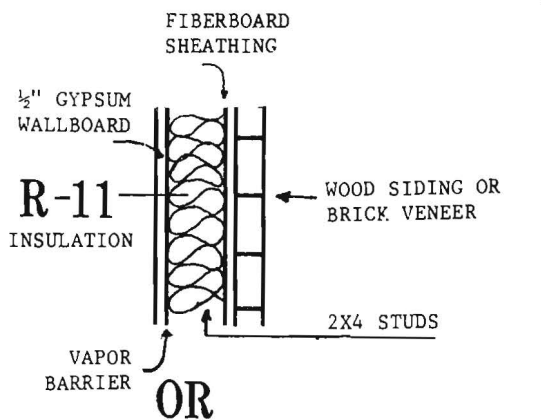
1. The Georgia Code allows R-11 wall insulation with single pane glass up to 15% (based on wall area). R-19 insulation is required with more than 20% single pane glass, based on wall area. North Georgia is considered to be Savannah and Albany and north.
2. FHA-HUD specifications prohibit more than 15% glazing, based on exterior wall area. The Home Builders Association of Georgia has adopted this as a minimum standard, along with their seven year maximum payback rule for energy packages. North Georgia is considered to be north of Macon.
3. Farmers Home Administration will loan on the construction of cathedral ceilings, sliding glass doors, and fireplaces only if they can be justified under their program. They permit the construction of a flue for a woodburning stove if conditions warrant it. A poly vapor barrier is required for the walls. The R-16 figure for walls in north Georgia includes insulation and sheathing. North Georgia is considered to be north of Macon.

General Note

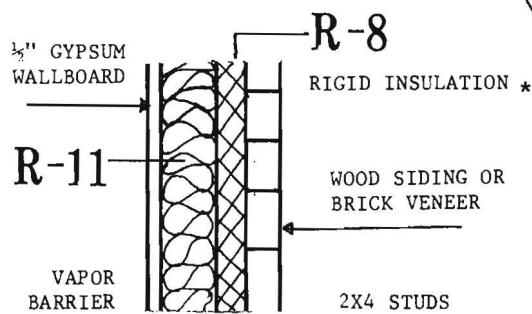
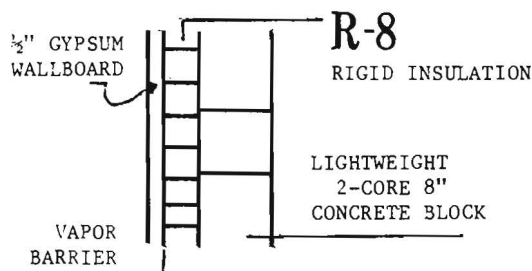
4. The dividing line for north and south Georgia differs for these three codes, check with your local representative to be sure of requirements in your area.

WALLS

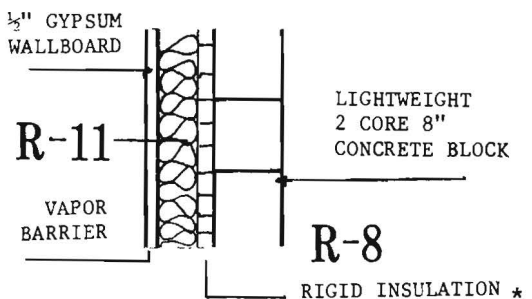
CEILING/ROOF



IF UNDER
20% GLASS
IN WALLS

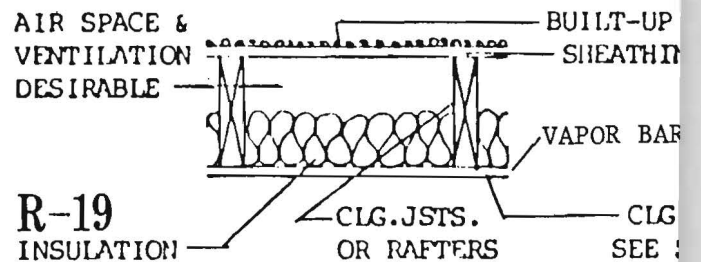
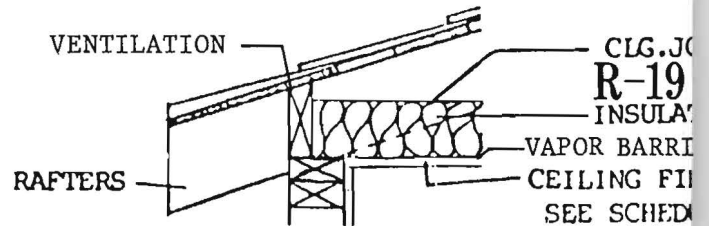


IF OVER
20% GLASS
IN WALLS

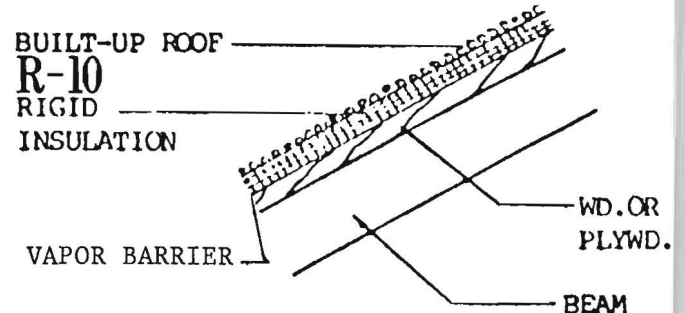


IF INSULATING GLASS OR STORM WINDOWS ARE INSTALLED, R-11 ALONE IS SUFFICIENT FOR WOOD STUD CONSTRUCTION, AND R-8 ALONE IS SUFFICIENT FOR CONCRETE BLOCK CONSTRUCTION UP TO 25% GLASS IN WALLS.

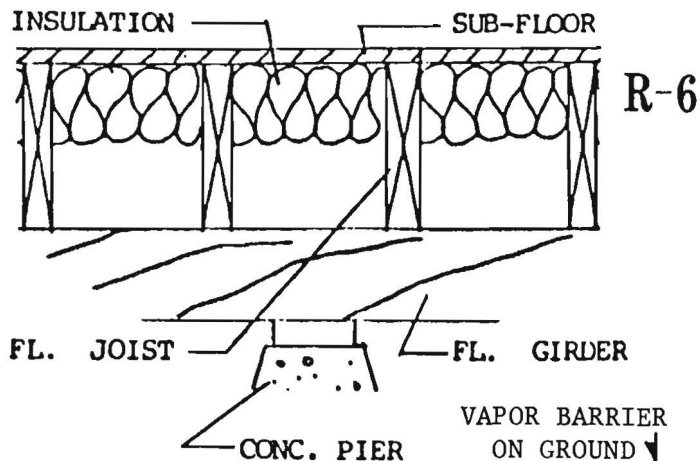
* R-5 MAY BE USED INSTEAD OF R-8 FOR AREAS SOUTH OF MARIETTA AND GAINESVILLE.



CATHEDRAL TYPE CEILING



FLOORS



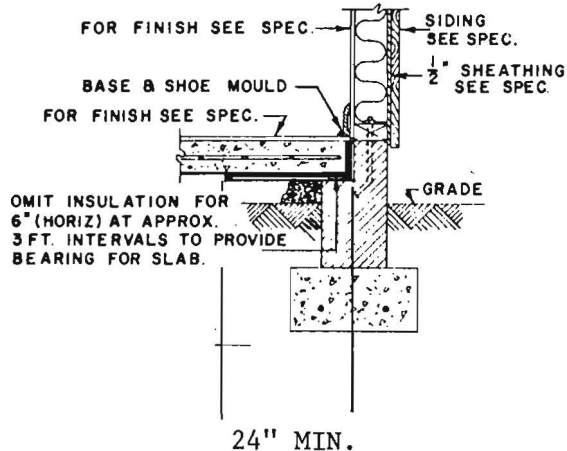
R-11 IS SUFFICIENT IN ALL CASES EXCEPT FOR A FEW AREAS IN EXTREME NORTH GEORGIA.

IN SOUTH GEORGIA (i.e.-SAVANNAH & ALBANY) NO FLOOR INSULATION IS NEEDED IF CARPET AND PAD ARE INSTALLED. R-4 IS SUFFICIENT WHERE THERE IS NO CARPET AND PAD.

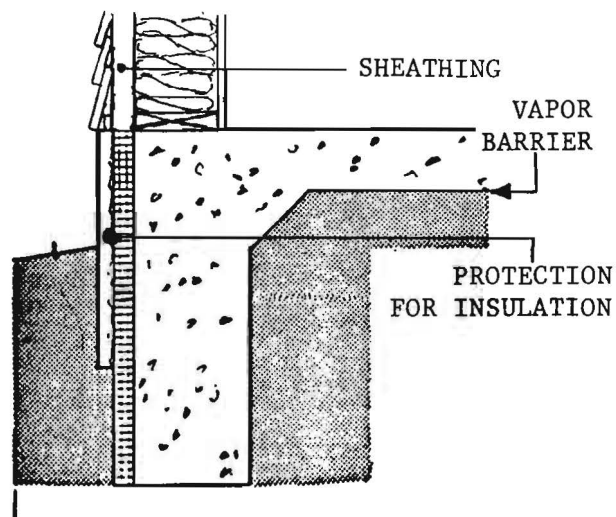
* IF FLOOR IS OVER A HEATED BASEMENT, NO INSULATION IS REQUIRED.

SLAB PERIMETER

RIGID INSULATION (SEE BELOW)



OR



RIGID INSULATION
(SEE BELOW)

FOR A HEATED SLAB ON GRADE, R-6
FOR AN UNHEATED SLAB ON GRADE, R-4

COMPARISON OF ENERGY CODES FOR SOUTH GEORGIA
Insulation Required for Residential Construction



	Georgia Code	FHA ² HUD	Farmers ³ Home Administration
Ceiling	R-19	R-19	R-26
Cathedral Ceiling	R-10	R-19	----
Walls	R-11 ¹ R-19 ¹	R-11	R-11
Floors over crawlspace	Carpet and Pad, or R-4	None Required	R-11
Slab-on-grade	R-0, R-4 if heated	None Required	None Required
Windows			Storm or Double
Doors	Weatherstripped	Solid Core, Weatherstripped	Solid core, weather- stripped or hollow core with storm

NOTES:

1. The Georgia Code allows R-11 wall insulation with single pane glass up to 15% (based on wall area). R-19 insulation is required with more than 20% single pane glass, based on wall area. South Georgia is considered to be Savannah and Albany and south.
2. FHA-HUD specifications prohibit more than 15% glazing, based on exterior wall area. The Home Builders Association of Georgia has adopted this as a minimum standard, along with their seven year maximum payback rule for energy packages. South Georgia is considered to be south of Macon.
3. Farmers Home Administration will loan on the construction of cathedral ceilings, sliding glass doors, and fireplaces only if they can be justified under their program. They permit the construction of a flue for a woodburning stove if conditions warrant it. A poly vapor barrier is required for the walls. The R-11 figure for walls in south Georgia includes insulation and sheathing. South Georgia is considered to be south of Macon.

General Note

4. The dividing line for north and south Georgia differs for these three codes, check with your local representative to be sure of requirements in your area.

few numerical calculations. The two-page chart shows typical constructions and the corresponding insulation that would satisfy the code requirements. This quick reference chart is the centerfold of the book and may be torn out for easy reference. The pull-out also contains a comparison of the Georgia Code with FHA-HUD and Farmers Home Administration requirements.

The component performance method allows more flexibility in the design of the house. If more glass is desired or less insulation than shown on the chart is desired for the walls or floor or ceiling, insulation can be added in places to account for the change. The procedure to be followed in this case can be found in Chapter V of the Code.

The alternate design method gives maximum flexibility in the design of a house. It allows for innovative features such as passive or active solar systems to be used in minimizing the energy requirements of the structure. The procedure for this method is found in Chapter IV of the Code.

The following is a fact sheet with the most frequently asked questions and answers.

Q - How was the code developed?

A - The State Building Administrative Board selected a special energy advisory committee, which included representatives from the board's State Code Advisory Committees on Heating and Air Conditioning, Plumbing, Building, and Electrical. Seven public hearings were held for comments.

Q - Does the code apply statewide?

A - The code applies everywhere in Georgia as part of the Energy Conservation Building Standards Act of 1978. The code was adopted on July 16, 1978.

Q - Does the code apply to all buildings?

A - The thermal standards in the code apply to all new and renovated buildings, except certain exempt ones, and the lighting standards apply to all buildings used by the public which excludes residential buildings.

Q - Who is responsible for enforcement of this code developed by the State Building Administrative Board?

A - The act specifically provides that enforcement shall be solely the province of local governing authorities, except in regard to buildings owned by the state.

Q - What about old buildings?

A - Existing buildings are not covered by the code, except when undergoing renovation.

Q - What does the code require?

A - The provisions of the code cover:

- (1) The design and construction of the exterior envelope (in terms of adequate insulation and low air leakage), and
- (2) The selection of efficient heating, ventilating, and air conditioning equipment, service water heating and usage, and electrical distribution and the selection of lighting for all buildings except residential.

Q - What are the requirements for residences other than insulation?

A - The requirements include:

- (1) Perimeter slab insulation (amount determined by location).
- (2) Shower restricters with a total flow of 3 gallons per minute.
- (3) Gas-fired heating equipment (includes HW heaters) to have a combustion efficiency of 75% or better.
- (4) Manual or automatic thermostats for heating and cooling to have a 55 degree to 85 degree setting range with a maximum setting of 75 degrees F for heating and a minimum setting of 70 degrees F for cooling.
- (5) Air leakage will be controlled by requiring tight fitting windows.
- (6) Return air ducts in unconditioned spaces shall be fully insulated according to location of residence.
- (7) All exterior joints are to be caulked, gasketed, weather-stripped or otherwise sealed to reduce air leakage and heat loss.

Q - Does the code require maximum insulation in attics?

A - No. In residential construction, R-19 insulation will be sufficient according to the code. However, if one wants a large picture window, the code permits it if more insulation, R-22 or R-30, is used in the attic to compensate for the greater heat loss through the larger window.

Q - Does this mean increased residential construction costs?

A - No. Generally, the code may increase the cost of the exterior walls, floors, and roof due to more insulation. However, this increase is offset by the savings in smaller but adequate heating, ventilating, and air conditioning systems. Furthermore, the code-built residence should save at least 5% per year in energy.

Q - What are the possible consequences if we fail to build by an energy conservation code?

A - The U.S. Department of Housing and Urban Development is formulating national thermal efficiency standards for new residential and commercial buildings. After these standards are promulgated in 1980, all federal financial assistance for new construction, including mortgage guarantees, may be terminated in areas which have not adopted equally stringent thermal standards. Building by the Georgia State Energy Code for buildings may avoid federal pre-emption.

CHAPTER 7

THERMAL INSULATION AND INFILTRATION AND VAPOR BARRIERS

This section covers the two most important areas of energy conservation, insulation and infiltration barriers. The third area is on vapor barriers, which are used in conjunction with insulation.

Energy conservation in the shell of the building starts with thermal insulation to retard the flow of heat, the application of vapor barriers to preserve the insulation and structure of the house, and infiltration barriers to cut air leakage.

The following areas are covered in depth:

1. Thermal Insulation
2. General Notes on Insulation
3. R factors and Cost of Typical Materials
4. Importance of Vapor Barriers
5. Types and Installation of Vapor Barriers
6. The Cost of Infiltration
7. Sealing the Sill Plate
8. Caulking and Sealers for Infiltration Control

Thermal Insulation

Thermal insulation is used to retard the flow of heat. Houses lose and gain heat three ways: conduction, convection, and radiation. Common insulating materials reduce heat flow by conduction; they have little effect on radiant and convective heat transfer.

There are two benefits of adding thermal insulation:

1. Money and energy are saved. Less heat is lost in the winter, and less air conditioning is needed in summer.

2. More comfort is provided. Walls, ceilings, and floors will be closer to the temperature of the air in the room, rather than to the conditions outside.

As fuel costs rise, the economic thickness of insulation increases. The economic thickness is the amount of insulation which yields the lowest total cost per year for utility bills plus mortgage payments for the cost of the insulation. In essence, the owner of a building wants to pay the lowest 'comfort cost' per year, which will be the sum of the utility cost and the yearly mortgage bill for insulation. There is not one "optimum R factor." The economic thickness of insulation varies with energy, insulation, and installation costs. The cost per R factor for widely used insulating materials is given later in this chapter.

General Notes on Insulation

There are three basic types of insulation commonly used in new construction. Fiberglass is the best all around insulation for most purposes. While it is fire resistant, it should be noted that the vapor barrier is not. Rigid foams are now in use, primarily for wall sheathing. They are more expensive than fiberglass per R value, but they are used for purposes for which fiberglass is not suited. The polystyrene and urethane foams are the most flammable and must be covered with sheetrock to pass code. The polyisocyanurate types are the most fire resistant, but require poly vapor barriers. Rock wool is a good material for attic insulation. Cellulose insulation is also good for attics, and some insulation installers can spray it into the wall cavity with a binder to keep it in place. Fire resistance of this material is dependent on chemical treatment. Pending legislation in Washington would upgrade and standardize testing procedures

to assure more fire resistance and quality control.

The new test for fire resistance is HHI-515D, a GSA specification. Cellulose insulation must be rated Class I, less than 25 flame spread. The Consumer Products Safety Commission and Federal Trade Commission are involved in setting up these safety and reliability guidelines. It is recommended that this material be kept 3" away from heat sources such as recessed spot lights.

Urea formaldehyde 'wet foam' insulation has made little penetration in the new home market. The product is relatively new and is used only in walls. The possible shrinkage of the material, formaldehyde odor, and high price are its drawbacks. Installed cost is about 4 times as much as R-11 fiberglass.

Foam core insulated doors are made with a variety of core materials. The door leading to the garage must be fire rated; these are available from most of the insulated door manufactures.

R factors and Cost of Typical Materials

R factor is a number used with insulating materials. It is proportional to the resistance of the insulation to heat flow; the higher the R value, the better the insulating capability of the material. It is defined as the thermal resistance to heat flow for a given thickness of the insulating material.

The following is a table of R values for commonly used insulating materials.

<u>Material</u>	<u>R Value per 1" Thickness</u>
1. "Thermax" or "High-R" or "Climate Guard"	8.0
2. "Styrofoam"	5.41

<u>Material</u>	<u>R Value per 1" Thickness</u>
3. White bead board, "Supersheath" "Super-R Plus"	4.25
4. Urea formaldehyde wet foam	4.2
5. Cellulose - blown	3.7
6. Rock wool, glass fiber - batts or blankets	3.2
7. Perlite and vermiculite	2.6
8. Fiberboard sheathing	2.6
9. Rock wool - blown or poured	2.5
10. Glass fiber - blown or poured	2.2
11. Pine	1.3
12. Gypsum board (drywall)	0.9
13. Common brick	0.2
14. Concrete	0.08

The following table is a cost comparison for cost of insulating materials. These prices vary with time, locality, and thickness of material and are only an approximate guide. Rigid foam prices are based on 3/4" thick sheets and batts are loose fill on 3-1/2" thickness.

These prices are for Atlanta, October 1978.

<u>Cost Comparison (for materials only)</u> <u>(not including installation)</u>	<u>Approximate cost,</u> <u>Cents per sq. ft. per R value</u>
1. "Thermax" or "High R"	3.2
2. "Styrofoam"	4.4
3. "Supersheath"	5.8
4. White bead board	3.5
5. Urea formaldehyde foam	1.5
6. Glass fiber - batts or blankets	0.9
7. Glass fiber - blown or poured	0.9
8. Cellulose	0.8
9. Fiberboard sheathing	5.3

Note that you are trying to buy resistance to heat flow, not thickness of material. The material which is lowest in cost per R factor is always the best buy if the installation cost is the same for both materials.

Importance of Vapor Barriers

Vapor barriers reduce the rate of flow of water vapor. They are used on walls, floors, and ceilings of residential construction to prevent

water vapor from entering the insulation in large enough quantities to cause condensation. When water vapor touches a cold surface below the dewpoint temperature of air at the point, the water vapor condenses to liquid water and wets the insulation. This causes a loss of insulating capability and possible rotting of the wood and peeling of exterior paint. Vapor barriers are especially important in kitchen and bathroom areas where high concentrations of water vapor exist. Extra care should be taken in these areas to provide a continuous and undamaged vapor barrier. Vapor barriers are also installed on top of the earth in the crawlspace of a house to keep the crawlspace and flooring dry.

Finally, vapor barriers help produce a better living environment in the house by keeping it drier in the summer and maintaining higher humidities during the winter.

From the builder's standpoint, installing the minimum amount and type of vapor barrier is best because it keeps costs down. Do not use a more expensive vapor barrier system than the wall sheathing requires. These requirements are covered in the material which follows.

Types and Installation of Vapor Barriers

There are three common types of vapor barriers used in residential construction. Vapor barriers are generally made of asphalt coatings, plastic films, or metallic foils. The most common is asphalt-coated back-up paper found on batt and blanket fiberglass. This material offers adequate protection for all installations except when used with foil-faced, rigid foam wall sheathing. The paper (sometimes called asphalt impregnated Kraft paper, or just Kraft paper) is also used to staple the insulation to the framing. Care should be taken to repair tears in this material; use

duct tape for this purpose. The second type is foil-backed gypsum board or drywall. This is frequently used for ceilings where blown insulation, which has no vapor barrier of its own, is to be installed. This vapor barrier offers adequate protection except with some foil-faced wall sheathings such as "Thermax" and "High R." Polyethylene plastic film is the third vapor barrier in widespread use. It offers superior protection to asphalt paper or foil-backed sheetrock. A 6 mil thickness is adequate protection for all types of insulation. The 4 mil thick film is adequate for all rigid foam sheathing with or without foil facings, except for "Thermax" and "High R" which require the 6 mil thickness. Four mil polyethylene film is also used to cover damp earth in the crawlspace of the house to keep the crawlspace and flooring dry.

The asphalted paper vapor barriers are stapled to the face of the wall or ceiling framing members. They can be side stapled to the wall studs, but face stapling is preferred. For crawlspace installation, the vapor barrier is faced up to the floor and the fiberglass insulation is kept in place by spring wires or chicken wire. The asphalted paper always faces the heated side, that is, up against the drywall of walls or ceilings, and against the subfloor. If the drywall ceiling is already in place, batts or blankets of insulation are placed between ceiling joints, again with the asphalted ("Kraft paper") side facing down against the drywall or gypsum board.

Foil-backed drywall has a thin aluminum foil vapor barrier on the side that faces the wall stud. The drywall is installed normally. The insulation used with this system needs no vapor barrier.

Polyethylene film is installed after wall insulation is in place

and before or after ceiling insulation is installed. Sheets of this plastic film are stapled in place. After stapling, holes are cut out for windows and doors. The material is stapled to the wall studs and ceiling joists on the inside of the framing and then the drywall is installed over it.

It is worth repeating that all vapor barriers are installed facing the living area. Never reverse the vapor barrier and place it on the outside of the wall or top of the ceiling joints. Always face the vapor barrier up, facing the subfloor in crawlspace or basement installation. If excess moisture exists in the crawlspace, cover the damp earth with 4 mil polyethylene; do not turn the vapor barrier face down on fiberglass insulation installed under the floor in an attempt to cure this problem.

The Cost of Infiltration

Energy conserving construction means tight construction. More insulation and better equipment can help, but the house must be tightly constructed in order for insulation to do its job effectively.

Infiltration costs money. A good value for total infiltration in residential construction is 1 air change per hour! Under average conditions, all the air in the house leaves and is replaced by outside air at ambient temperature each hour. This causes higher heating and cooling bills, higher humidity during the summer, and drier air during the winter. Infiltration may be up to 40% of the heating and cooling load of a well-insulated house.

Where does all this air leak into and out of the house? The following table shows test results on a 1,780 square foot house.

<u>Infiltration Area</u>	<u>Percent</u>	<u>Air Changes per Hour*</u>
1. Soleplate	25%	0.25

<u>Infiltration Area</u>	<u>Percent</u>	<u>Air Changes per Hour*</u>
2. Wall outlets	20%	0.20
3. Duct System	14%	0.14
4. Windows	12%	0.12
5. Range Vent	5%	0.05
6. Fireplace	5%	0.05
7. Exterior Doors	5%	0.05
8. Recessed Spotlight	5%	0.05
9. Dryer Vent	3%	0.03
10. Sliding Glass Door	2%	0.02
11. Bath Vent	1%	0.01
12. Other	3%	0.03

Annual Cost per 1,000 square feet for 1 Air Change per Hour

	<u>Gas + A/C</u>	<u>All Electric</u>	<u>Heat Pump</u>
Heating	\$29	\$70	\$31
Cooling	<u>17</u>	<u>17</u>	<u>17</u>
Total	\$46	\$87	\$48

*Based on 1 air change per hour under average conditions.

With these figures for the Atlanta area, the sole plate which 'leaks' 0.25 air changes per hour would cost \$11.50 \$21.75 and \$12.00 per year for gas and A/C, all electric, and heat pump systems respectively.

The area of largest loss is a surprise - not the windows and doors - but the soleplate leads the list.

1. The solution is simple - apply a bead of caulk between the soleplate and flooring or slab during installation. An alternate is to caulk the interior crack between the soleplate and flooring after it is secured. Urethane wet foams can be used for the application.

2. The second largest area is the electrical outlets on exterior walls. Caulk the wire and pipe holes where they penetrate the upper and lower wall plates, and pack the wall insulation behind the outlet box.

3. The duct system leaks can be reduced by taping the seams before

applying duct insulation. Tape is still needed to contain the air in the duct; the insulation is not designed to do this.

4. Window infiltration was primarily leakage around the frame. The shim space between the rough opening and frame should be packed with insulation and covered with a vapor barrier. It can also be filled with urethane foam.

5. The range vent should have a back draft damper. The area around the vent duct should be sealed where it penetrates the wall or ceiling.

6. The fireplace damper is the leakage point. Glass doors in front of the fireplace and exterior combustion air ducts can cut this loss.

7. Standard exterior doors can be replaced with foam core doors with superior weatherstripping.

8. Recessed spotlights and sliding glass doors should be avoided.

9. The dryer vent should have a back draft damper. Joints should be sealed with tape.

10. Sliding glass doors should be avoided; foam core doors, especially french doors of this type, will let in the view with lower heat loss.

11. The bath vent should have a back draft damper; seal the space between the sheetrock and the fan shroud.

Sealing the Sill Plate

Sill plate infiltration was not included in the above tests, but can cause higher heating and cooling bills in houses which have a finished basement. A house built over a crawlspace which contains no fuel-fired appliances (furnace or hot water heater using gas or fuel oil) should also be sealed. If it contains fuel-burning appliances, a sealer is not necessary or desirable. Sealing is accomplished by running a bead of caulk down the center of the foundation before the sill plate is bolted

down. Another product used for this purpose is "sill sealer" which is fiberglass material 1" thick and 4" wide. It is unrolled along the top of the foundation before the sill plate is bolted down, in effect, becoming a gasket between the sill plate and foundation. New polyurethane foams are available which can seal this crack after the sill plate is placed. The foam is applied as a bead on the inside of the sill plate. It comes in pressurized aerosol cans and has much the same consistency as shaving cream before it dries. This system cannot be used where the dried foam will be subjected to sunlight, as the ultra-violet portion of sunlight will cause the foam to disintegrate in a matter of months.

Caulking and Sealers for Infiltration Control

Caulking is used to seal around openings (doors, windows, etc.) to keep air and water from passing through these cracks into the house. Since they are used on the exterior of the house, they are exposed to the weather and sunlight. Poor quality caulk will weather, harden, and fall out of these cracks in a short time. It pays to use higher grade, longer lasting caulks on the exterior of the house. Remember the relation of caulking, cracks, and air infiltration - these cracks will add about \$20 per year to the heating and cooling bills of the average all electric house, and about \$10 per year for a natural gas/electric house. Since caulking is always applied to a new house, the only extra cost involved in sealing these cracks is the extra cost of a better caulk. The ideal caulk would be easy to apply, have good adhesion, and stay flexible indefinitely.

a. Oil Base

Oil base caulking is the oldest and usually the cheapest caulking

available. In general, oil base caulks have the shortest life. (There are exceptions, however see Consumer Reports, May 1976, pg. 291, for brand name comparisons). Oil base caulks are more than adequate for interior caulking jobs. Many oil base caulks are difficult to tool smoothly.

b. Acrylic Latex and Latex

These two caulking materials offer better resistance to aging than most oil base caulks at slightly higher cost; they also are easy to tool smoothly after application.

c. Butyl Rubber

Butyl rubber also offers better resistance to aging than most oil base caulks at moderately higher cost. Most are difficult to tool smoothly.

d. Polyurethane, Polysulfide and Silicone Rubber

The polyurethane, polysulfide, and silicone rubber caulks offer better resistance to aging than most oil base caulks, at a much higher cost (several times the cost of oil base caulk). Some types are difficult to tool smoothly, and most silicone rubber products cannot be painted. Other than these two problems, silicone rubber caulks are excellent, except for their high price.

e. Fillers

Large, deep cracks must be filled to within 1/2" of the surface in order to retain caulk and cut waste. Fill the crack with oakum, wood, cotton, glass wool, or other inert material before applying caulk.

f. Summary

A good oil base caulk or latex or acrylic caulk is the most economical choice. Price is not always a good guide to performance. Check test data for better brands. Synthetic rubber caulks may give superior results, but

have high cost and are difficult to tool.

g. Interior Wet Foam Sealants

A relatively new product is on the market which is used to seal the wall cavity from the inside. These are polyurethane base wet foams which come in a can. "Monofoam" and "Polycel One" and "Insta foam" are three of the brands currently available. While a standard tube of caulking compound will produce a 1/4" bead 25' long, a small aerosol can of foam (selling for about \$8 a can) will produce about 25 times as much bead at an obvious cost saving. This material cannot be used on the exterior of a house, as sunlight degrades it. It is a logical choice for sealing around the sole plate, door and window frames, and piping and wiring holes which are protected from sunlight. Very large cracks can be filled with fiberglass or other insulating materials at a lower cost, and topped if necessary, with wet foam sealant.

CHAPTER 8

PASSIVE SOLAR ENERGY DESIGN IN RESIDENTIAL CONSTRUCTION

Passive solar systems use the building as the collector and storage system. The word "passive" means that no fans or pumps are used; heat moves on its own by conduction, convection, and radiation.

There are two distinct areas of passive design that home builders should understand:

1. Summer design consists of proper orientation of the house on the lot, and shading of windows to decrease solar heat gain, thereby reducing air conditioning costs.

2. Winter design attempts to let in the sun and store the heat gained from the sunlight, while minimizing heat loss.

Summer Design and Site Orientation

The roof ridge on a house with a standard gable roof should run east and west. The roof eave on the south side should extend 18" to 24" past the south wall of the house. On two-story houses, a setback (cantilevered design) at the second floor can shade the lower story. This eave will shade the south windows during midday in the summer, and also allows sunlight to penetrate during the winter.

Windows on the west side of the house let in large amounts of heat during the late afternoon. The solar load developed by an unshaded single pane window facing west is about one ton per 100 square feet of glass (using Manual J figures). In contrast, a shaded, double pane window develops a one ton air conditioning load per 420 square feet of glass.

The best method of cutting this load is to eliminate or limit the west facing glass by placing the garage on the west side of the house. Other methods are shade screen, large pine or hardwood trees, or awnings.

The diagram at the end of the chapter shows these relationships.

The windows which face east generate nearly the same air conditioning load and should be shaded. The east windows generate their peak load in the morning when it is cool and shading them is less critical than west windows. As noted in the chapter on New Construction Techniques, even white, opaque roller shades can help. Adding one to a double pane window facing east or west decreases the air conditioning load 20%.

North windows let in diffused light during most of the year. In midsummer, a few hours of direct sunlight may pass through them, but the air conditioning load developed is small.

Porches can help shade the glass on the house. A short porch is all that is necessary on the south side. A porch on the east or west side must be quite wide (6' to 8') in order to effectively shade the wall and glass. In addition, positioning a screened-in porch used for eating on the west side is not recommended. The summer sun will heat the porch and its occupants when they are most likely to use it, at dinner time. The east or south side would be cooler at this time of day.

Winter Design for Solar Heating

In all of Georgia, a double pane glass window which faces south will gain more solar heat during an average winter than it will lose. This simple fact opens the way for partial heating of homes with simple, passive solar energy.

As with many things that appear simple, there are complex factors that must be accounted for before we can make use of solar heat.

1. Storage

The solar radiation which enters south facing windows is converted to heat when it strikes the wall, floors, and furniture in a room.

Enough mass must be built-in to soak this heat up and release it at night.

2. Infiltration

If windows are poorly installed or of poor quality, air leakage will cancel out any solar gains.

3. Added air conditioning load

Even if the south facing glass is properly shaded, it will add to the air conditioning load by conduction heat gain, increasing summer air conditioning bills, even though it decreases winter heating bills.

These are the three main problems involved in passive heating design. The following information will give the builder a basic understanding of the solutions, and a basis for working with your designer or architect on these problems.

Design Considerations

The site should have a relatively unobstructed horizon to the south. Tall pine trees, or a hill to the south will reduce the number of hours of sunlight available. Five hours of sunlight on December 21st should be considered a minimum figure for a site. Hardwood trees to the south pose no problem if they lose their leaves early in the winter.

The house must include enough mass to prevent overheating and to save the heat for nighttime use. A rule of thumb is to have at least 1 cubic foot (150 lbs.) of concrete or 4 gallons of water in the rooms on the south side per square foot of glass. The mass should be directly exposed to the sun; if not, 4 times the mass is required. The concrete can be the floor slab, with beefed up perimeter insulation. The floor should not be carpeted; a quarry tile or cracked tile finish is best. The usual thickness of concrete required is 4" to 8", depending on the amount of glass. Mass can be built into the north wall of the room using concrete blocks filled with sand or an extra layer of sheetrock.

Water storage may be added later; it is accepted esthetically by some and rejected by many. Water usually is stored in fiberglass tubes or re-conditioned water drums. It can be concealed from view, but should be able to absorb direct sunlight. Low mass elements in the room should be light-colored to diffuse and reflect light; high mass elements should be dark, but need not be black. There should be about 3 feet of exposed surface of the mass per square foot of glass.

The amount of glass in the south wall should not exceed $1/4$ of the conditioned floor area in the rooms to be heated. A typical 1600 square foot house could have up to 400 square feet of glazing on the south side. In order to install this much glass, the house would need to be long and narrow. A 25' X 64' house would still have 80% of the south side glazed if the full 400 square feet were used. This amount of glass would provide about 40% of the space heating load, the remaining 60% being provided by the standard heating system. These figures apply to a well-built energy conserving house, not standard construction.

Much of the glass should be fixed to eliminate infiltration, and the shim space between the rough opening and the window trim should be sealed and insulated.

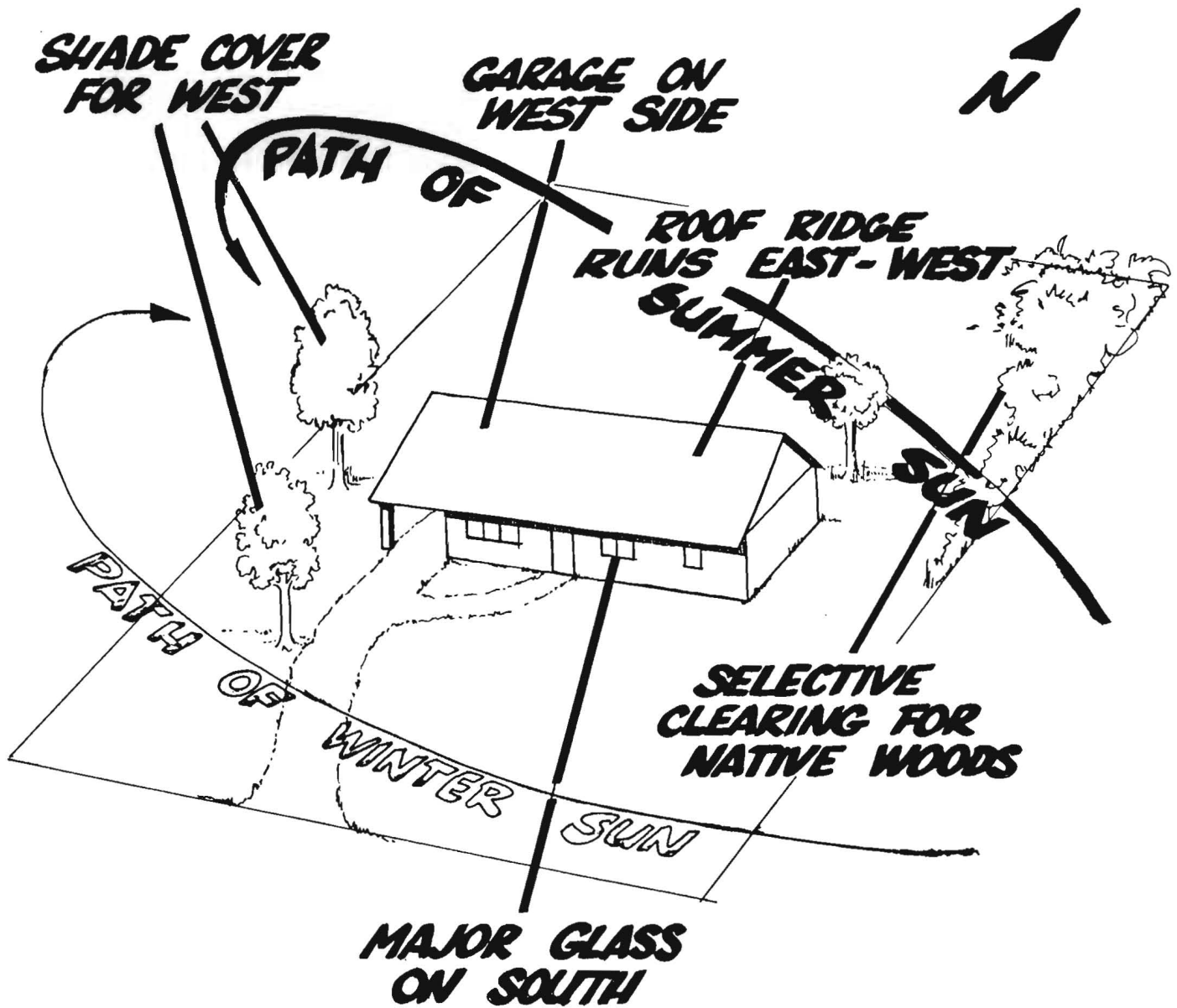
Daily temperature swings in the solar heated portion of the house will probably be 15° to 20° F. Overheating of the space, with loss of efficiency and decreased savings and comfort must be avoided. Enough mass must be provided for each square foot of window, and the amount of glazing should not exceed the $1/4$ rule stated above. Attempts to provide more than 50% of heating with this passive system will increase the odds that overheating will occur.

The net heat gain for a properly designed passive system in Atlanta will be about 80,000 Btu per square foot of double pane glass per winter. At current fuel prices found in Appendix I, it will save 35¢, 41¢, 50¢, 82¢ per square foot of glass for natural gas, heat pump, fuel oil, and electric furnace heating systems. Using Manual J data, this glass, if properly shaded to eliminate solar gain during the summer, will add 18¢ per square foot per summer to the air conditioning bill. The heating savings versus air conditioning cost produce two concepts:

1. North Georgia, where heating needs predominate and little air conditioning is needed for a well-shaded house, is a prime candidate for this system.
2. The inclusion of interior or exterior insulating shutter systems on the south wall may be needed to shed the summer solar load in south Georgia and will also help cut night losses during the winter.

The economics of this system are highly dependent on efficient design and cost control by the builder. Using insulating glass made in standard sizes for sliding glass doors can keep the extra cost of the south wall to \$3 per square foot of glass. The extra cost for a tile floor over carpet and pad cost would be about \$3 per square foot of glass. Payback periods for a house with an electric furnace would be 9 years, for natural gas, 35 years, including the added cost of air conditioning. These payback periods can be improved considerably by using Kalwall or Filon fiberglass panels instead of glass. The owner of the house may also feel that the tile floor is desirable esthetically, outside of its solar function, in which case its cost may not be a factor. Finally, a house in the northern part of the state with higher heating and lower air conditioning costs would show a faster payback period.

SITE ANALYSIS



SELLING THE ENERGY CONSERVING HOME

Is Today's Homebuyer Ready for the Energy Conserving Home?

The contemporary homeowner and homebuyer are well aware of the high costs of their energy. They are also aware that utility bills will continue to be an increasing percentage of their monthly expenses. Homeowners are now looking beyond the initial cost for their homes and making critical evaluations of what it will cost to operate their homes five, ten, and fifteen years from now. A conservative estimate would be that, on the average, a typical Georgian is reminded 10 times per week, via mass media, signs, or at work, that some of our current fuels will eventually become in short supply, that energy costs are going up, or that energy conservation should be practiced at home or on the job.

Today's homebuyer is ready for the energy conserving home, and current sales of energy conserving homes support this statement. Many builders throughout the Southeast are altering their designs and building techniques to build only energy conserving homes. In the words of one southern builder:

"I took a hard look at the new design ideas and then sent my people back to the drawing boards to redesign all of the houses we had planned at the time. Actually, making the design changes doesn't take a great deal of doing; and in the average home, the cost differential will only be about \$1,000. But when the savings are measured for the buyer, month after month, year after year, why, this looks like the only logical thing to do".

In a recent survey, "Professional Builder" reported that 89.3 percent of actual buyers were willing to spend \$600 or more at the time of construction in order to cut their heating and cooling bills by \$100 per year.

One example of how well sales of energy conserving homes are going is that the largest home builder in the state of Virginia builds and markets only energy conserving homes.

The demand exists for energy conserving homes, and the progressive builder with insight into the changing home market will recognize this fact and gear up to supply them.

The Effect of Energy Costs On The Homebuyer

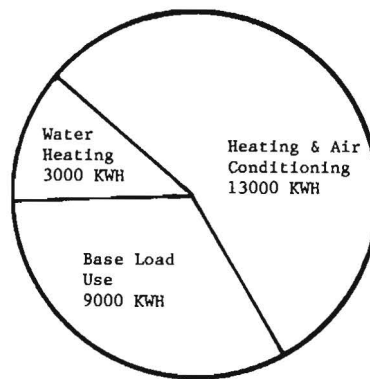
Notwithstanding the energy awareness of today's average person, the prospective homebuyer needs to have certain facts emphasized. For an average house with gas heat and electric air conditioning, utility bills equal 16% of the mortgage payment.

For all electric homes, this figure is 27%. The following table illustrates representative cost figures for the Atlanta area.

<u>Average Monthly Utility Bill</u>			
Sq. Ft. of House	Gas Heat, Elec, A/C	All Electric w/Baseboard Ht.	Monthly Mortgage*
			Payment
1200	\$ 50	\$ 87	\$ 330
1600	\$ 70	\$117	\$ 440
2200	\$ 88	\$158	\$ 605
Percent of Mortgage Payment	16%	27%	

*30 year mortgage, 9 3/4% interest, \$32 per sq. foot of conditioned space.

Heating and air conditioning constitute the major portion of the energy bill for the average home, with a substantial part of the remainder being made up by domestic hot water. The chart below illustrates results of a study performed to determine electrical energy usage patterns for typical new, single-family home construction by Gulf Power Company. It shows the predominance of heating and cooling as items making up the total energy bill.



Annual Energy Consumption in
New Single Family Residences

Since many new homes are constructed without adequate energy conservation features, much of the heat in winter, cool air in summer, and hot water year-round leaks or is directed out of the house, increasing the homeowner's costs with no net effect on comfort.

The figures given above have additional significance, when it is considered that:

- 1) Energy costs will continue to go up,
- 2) Mortgage payments to an existing loan are constant over the loan life, and
- 3) Money that is spent on a mortgage is an investment in one's home, while money spent on utilities yields no tangible, future return.

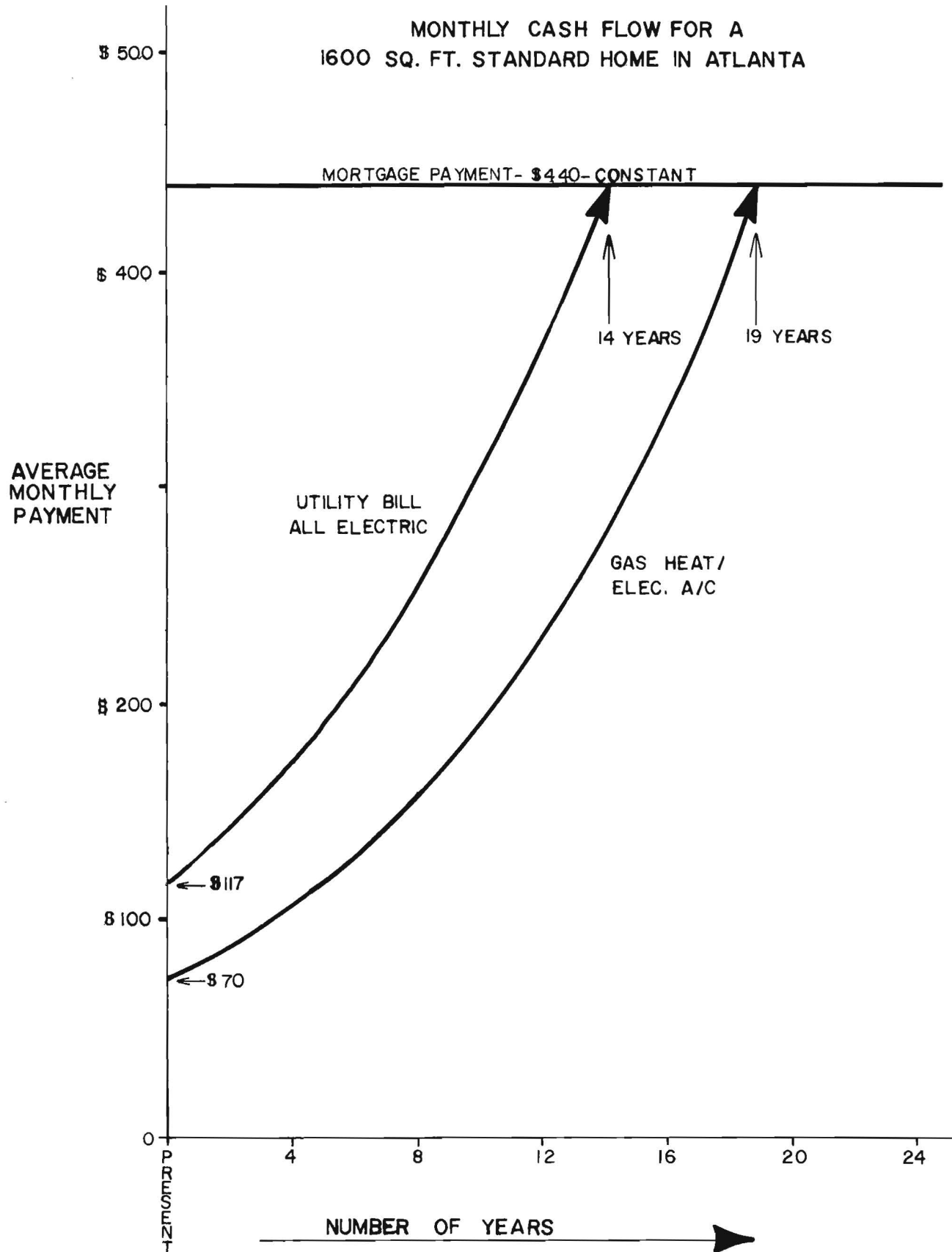
A further illustration to sharpen the prospective homebuyer's interest appears on the following page. The graph shows a projection of the change in utility bills versus mortgage payments, with time, assuming a 10% per year increase in energy costs. The graph shows rapid growth of utility bills, with the all electric house utility bill and mortgage payment becoming equal after 14 years; for natural gas heat, the figure is 19 years. In addition, the peak month utility bill will surpass the mortgage payment much sooner. This event has already occurred for many homeowners with all electric homes during recent winters; what is worse, cost increases could more than likely be higher than the 10% used in the graph.

By advising prospective homebuyers of these facts and offering the energy saving home as the solution, the builder, developer, and real estate agent will be satisfying market demands, selling homes faster, and making more money on slightly higher priced homes, while giving the homeowner the assurance of lowered energy use and costs.

From a benefit/cost standpoint, the following analysis would seem appropriate for today's homebuyer:

Monthly Cash Flow Based on 1,000 Sq. Ft. of House

First Cost to the Homebuyer	Less than \$ 1,000
Extra Mortgage Payment	\$ 8.59
Average Monthly Utility Savings, all electric	\$ 36.00
Average Monthly Utility Savings, gas - electric	\$ 22.00
Net Cash in Hand Savings to Homebuyer: All Electric	\$ 27.41
Net Cash in Hand Savings to Homebuyer: Gas - Electric	\$ 13.41



It should be re-emphasized that the extra mortgage payment of \$8.59 per month is "saved" also. The buyer is building equity in the house with it, and will recoup the money upon sale of the house. Savings may be be greater outside the Atlanta area where this energy cost data was derived.

Lenders will be pleased to note that there is a simple basis for this method of economic analysis: any energy conserving item which saves as much per month as it costs in mortgage payment (\$8.59 per month, per \$1,000 - first cost to the home buyer) has a simple payback period of 9.7 years. Also, for the homeowner, if the savings as a result of energy conserving features shown above were invested at 6% interest, the savings over the 30 year mortgage would be in excess of \$12,500.

The Energy Conserving Home Marketing Package

Two principles of importance apply here:

- 1) A package of energy conserving features is more desirable than one or two energy extras.
- 2) The marketing of the energy saving home requires the coordination and expertise of all of the people involved in the new home industry: builders, subcontractors, appraisers, lenders, real estate agents, and home buyers.

It is important to use a package of energy conserving features and, where possible, to standardize this package for a particular area. The use of a standardized package has the advantages of a) tightening up the house equally in all its weak areas, producing the greatest amount of comfort and savings, b) making the job of communication between builder and subcontractors, inspectors,

appraisers, lenders, sales agents, and home buyers easier, and, c) making easily obtainable, fully tested materials available instead of requiring that new, untried materials be used, thereby making it simpler to pass building codes.

Individuals outside the home building industry are often amazed at the complexity of the scheduling and coordination required to build and sell a house. This same scheduling and coordination are required to build and market the energy conserving home. The wise builder will make sure that the following people are completely aware of the energy saving plans and materials he has built into his homes:

1) Subcontractor:

The heating and ventilating contractors, insulators, and framing crews are at the heart of producing a tightly constructed, energy conserving home. They must be fully aware of new techniques and their part in the construction of the energy saving home.

2) Inspectors:

By building a standard energy efficient package into homes and informing the building inspector of the details of this package, the task of satisfying the building code will be simplified.

3) Appraisers:

Appraisers must be aware of all the energy saving features in a new home. Following this section is a sample "FHA Description of Materials Form" with energy extras noted for the energy conserving house plans, to illustrate the degree of detail which should be used.

Also, the most recent "Federal National Mortgage Association Residential Appraisal Report" form (FNMA Form 1004 and FHLMC Form 70, Revised 10/78), a form widely used in appraisal and lending circles, makes special emphasis of energy efficient items in the valuation process. Today, appraisers are giving energy saving features their due in terms of market value, but they can only include these features in their appraisal if they are aware of them.

4) Lenders:

Lenders are committed to a policy of fostering energy conservation in the construction of new homes. One of the considerations used in evaluating the allowable debt-to-income ratio for prospective buyers is whether the home has energy conserving features which would reduce the buyer's anticipated utility bills and hence, permit the lender to allow a slightly higher debt ratio. Real estate agents and home buyers in particular should be aware of this consideration. But, once again, the lender must know the extent and type of energy saving features. Another advantage to a builder of using a standardized package is that, by reputation, appraisers and lenders will come to expect or look for energy saving features from a particular builder.

5) Real Estate Agents:

Real estate agents, by and large, recognize the desire by the home buying market to purchase energy conserving homes. The time spent in informing sales people of the nature and significance of energy conserving features will be returned many times over by faster sales at slightly higher prices.

6) Home buyer:

The home buyer, in many ways, is the most easily sold. No one wants to buy an energy hog. But the buyer must know what will be gained by paying the slightly higher price for an energy conserving home:

- A) Lower utility bills.
- B) Improved monthly cash flow.
- C) Energy and dollar savings.
- D) Quality, tight construction.
- E) Greater comfort.
- F) Higher resale value.
- G) A hedge against increasing utility costs.

The buyer can be informed of the existence and benefits of energy saving features by the following methods, among others:

- A) Use of the "Home Energy Profile Card" shown at the end of this section. Fill it out when the house nears completion and hang it in a conspicuous place, where it can be viewed by the appraiser, buyer, or salesman. Copies are available from the Home Builders Association of Georgia.
- B) Certification, promotion, and advertising offered by public utilities.
- C) Tagging of energy saving features in model homes or in all homes.
- D) Preparation of a descriptive brochure or use of available, existing brochures to promote the benefits of energy saving features for prospective buyers.

E) Promotions to encourage energy conservation. For example, one developer in the Southeast has a promotional method in which he offers to pay the lowest monthly utility bill of the energy saving homeowners in his development. This approach stimulates interest in energy conservation by homeowners while giving the developer effective, low cost publicity.

In conclusion, the energy saving home has advantages that make it more desirable to home buyers than the conventional home. Through effective coordination, construction, and marketing of these homes, the far-thinking builder and home buyer are setting the trend for today's market.

HOME ENERGY PROFILE

THIS HOME CONTAINS THE FOLLOWING ENERGY
CONSERVATION FEATURES:

BATT OR BLOWN INSULATION

_____ INCHES — CEILING
_____ INCHES — WALLS
_____ INCHES — FLOORS

FOAM INSULATION

_____ INCHES LOC. AND TYPE _____
_____ INCHES LOC. AND TYPE _____

TOTAL INSUL. 'R' FACTORS

CEILING _____
WALLS _____
FLOORS _____

AIR INFILTRATION BARRIER

- ☐ SILL SEALER
- ☐ WIRING HOLES CAULKED
- ☐ PIPE HOLES CAULKED
- ☐ POLY VAPOR BARRIER
- ☐ ATTIC STAIR SEALED & INSULATED
- ☐ ATTIC STAIR IN UNCONDITIONED SPACE

ROOF

- ☐ LIGHT COLORED
- ☐ RIDGE AND SOFFIT VENTS
- ☐ WIND POWERED TURBINE VENT

WINDOWS AND DOORS

- ☐ STORM SASH
- ☐ DOUBLE PANE
- ☐ FOAM CORE STEEL DOORS

HEATING AND COOLING SYSTEM

- ☐ INSULATED DUCTS
- ☐ TAPED DUCT JOINTS
- ☐ HEAT PUMP: _____ TONS
- ☐ SPLIT (ZONED) SYSTEM
- ☐ HIGH EFF. A/C _____ EER (MIN. 9.0)
- ☐ SET BACK TYPE THERMOSTAT
- ☐ ELECTRONIC IGNITION ON FURNACE
- ☐ TIMER SWITCH ON EXHAUST FAN
- ☐ SOLAR

FIREPLACE

- ☐ GLASS DOORS
- ☐ EXTERIOR COMBUSTION AIR
- ☐ CIRCULATING FIREPLACE
- ☐ TIGHT-FITTING DAMPER

APPLIANCES & FIXTURES

- ☐ FLUORESCENT LIGHTS
- ☐ PILOTLESS IGNITION ON STOVE
- ☐ EXTRA INSUL. ON ELEC. WATER HEATER
- ☐ WATER-SAVING SHOWER HEAD
- ☐ LOW-FLUSH TOILET

OTHER ENERGY SAVERS

- ☐ OVERHANGS FOR SHADE — SOUTH SIDE
- ☐ GARAGE ON WEST SIDE FOR SHADE
- ☐ PORCH — EAST, WEST, OR SOUTH SIDE

☐ _____
☐ _____
☐ _____
☐ _____

BUILDER: _____ DATE: _____

TYPICAL ENTRIES FOR FHA 2005
DESCRIPTION OF MATERIALS FORM

5. EXTERIOR WALLS:

Additional information: Sole plate - latex caulking to flooring

6. FLOOR FRAMING:

Joists: wood, grade, and species _____; other _____; bridging _____; anchors _____
Concrete slab: ☐ basement floor; ☐ first floor; ☐ ground supported; ☒ self-supporting; mix _____; thickness _____";
reinforcing _____; insulation _____; membrane _____
Fill under slab: material _____; thickness _____". Additional information: _____

12. ROOFING:

Additional information: light in color

15. DECORATING: (Paint, wallpaper, etc.)

Additional information: Wire and pipe holes latex caulked

17. WINDOWS:

Weatherstripping: type _____; material _____ Storm sash, number X

18. ENTRANCES AND EXTERIOR DETAIL:

Main entrance door: material See Below; width _____; thickness _____". Frame: material _____; thickness _____"
Head flashing _____ Weatherstripping: type Mag. and compression
Additional information: Steel faced foam core insulated doors

22. PLUMBING:

FIXTURE	NUMBER	LOCATION	MAKE	MFR'S FIXTURE IDENTIFICATION NO.	SIZE	COLOR
Water closet	X	X	X	X	3 1/2 Gal. Water Saving	
Bath tub						
Shower over tub Δ	X	X	X	X	3 GPM Water Saving	
Stall shower Δ						
Laundry trays						
Aerators	X	X	X	X	2 GPM Water Saving	
Water pipes					Pipe Insulation at Hot Water Heater	

23. HEATING:

Warm air: ☐ Gravity. ☒ Forced. Type of system Gas Furnace
Duct material: supply _____; return _____ Insulation Fiberglass, thickness 2" ☐ Outside air intake.
Furnace: make and model _____ Input _____ Btuh.; output _____ Btuh.
Additional information: Duct joints taped, pilotless ignition on furnace
Other heating, ventilating, or cooling equipment continuous ridge and soffit vent, EER 9.0 air conditioner, air conditioner heat reclaimer, solar etc.

25. LIGHTING FIXTURES:

Nontypical installation Number and location of Fluorescent light fixture.

26. INSULATION:

LOCATION	THICKNESS	MATERIAL, TYPE, AND METHOD OF INSTALLATION	VAPOR BARRIER
Roof			
Ceiling	R-26	Fiberglass, 8 1/4"	Kraft Face
Wall	R-17	R-13 Fiberglass batt + R-4 rigid foam wall sheathing	Kraft Face
Floor	R-11	Fiberglass batt	Kraft Face
or	R-4	One inch - Beadboard perimeter insulation, 24"	

SPECIAL EQUIPMENT:

Pilotless ignition on range (make and model #)

Also prepare a separate sheet entitled "Addendum to 2005", note section numbers which contain energy conserving items, explain their function if necessary. Make a note on page one of 2005; "To the attention of the appraiser, see Addendum to 2005 on energy conserving items".

CHAPTER 10

SUMMARY

The energy conserving home can be built now, for little extra cost and with available materials. For about 3% extra cost to the homebuyer, the heating and cooling utility bills can be cut in half. The 'package' approach is best, not just adding a feature here and there.

The following energy dos and don'ts will be useful reminders when designing the energy conserving house.

DO

- Consider site orientation and shading
- Use a package approach
- Use natural attic ventilation
- Install fluorescent lights
- Use a cashflow sales approach
- Use tested materials and products
- Minimize the amount of windows
- Check 'subcontractors' work
- Duct exterior combustion air to furnace
- Choose compact house designs

DON'T

- Allow oversizing of equipment
- Install needless appliances and equipment
- Make inflated claims
- Outprice yourself from the market

APPENDIX I
SEASONAL HEATING COSTS

The graph on the following page shows the dramatic effect that the R factor and its reciprocal, U, have on heat loss.

Even small improvements in the R factor at low R's produce large savings, as in the case of adding storm windows or insulating an uninsulated attic or heating ducts. Adding more insulation to an already insulated area, such as going from R-19 to R-26 attic insulation, yields smaller savings. The law of diminishing returns works against us at higher R factors.

This graph may be used for the Atlanta area at present utility rates. The following data were used in its preparation:

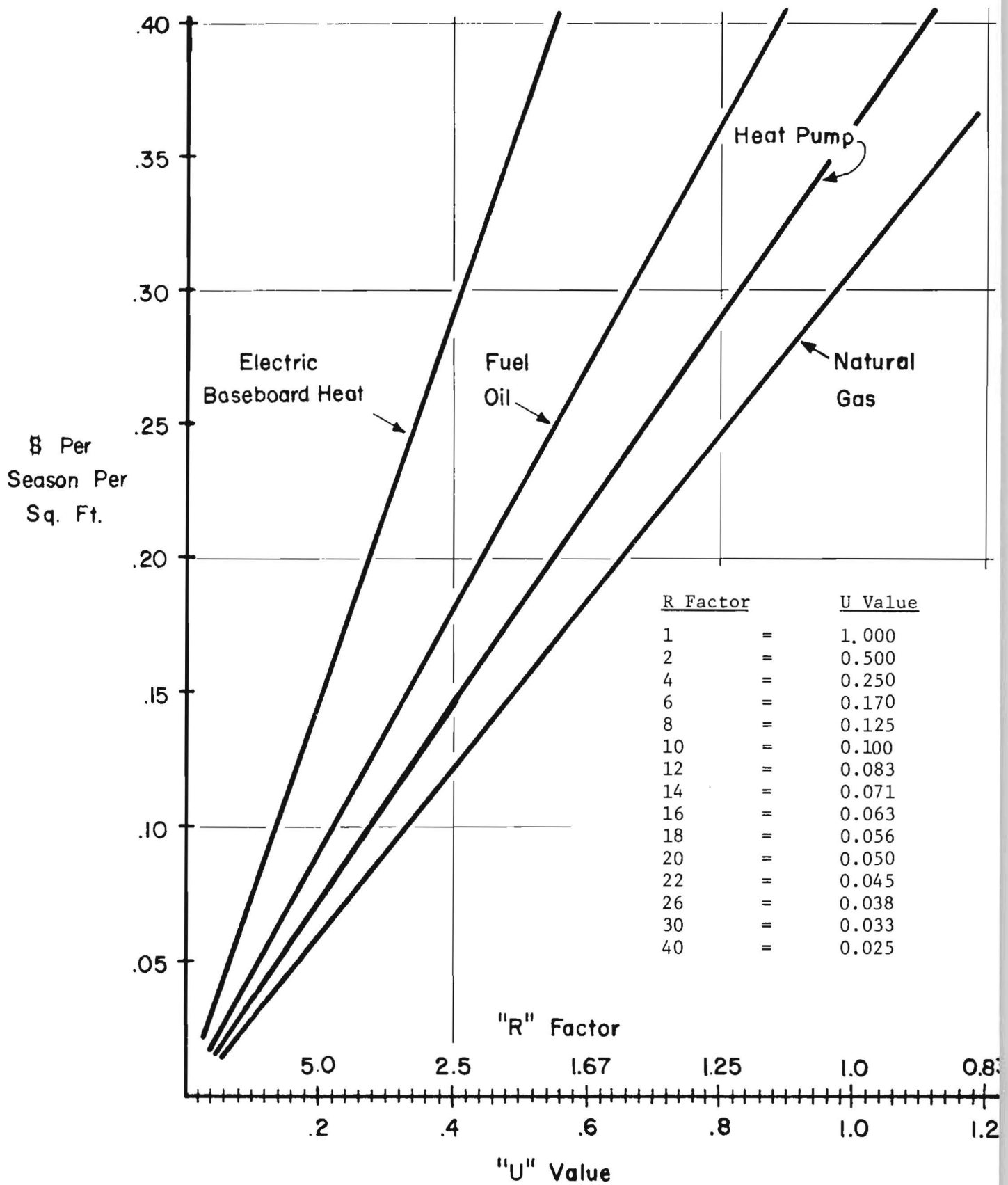
<u>Fuel</u>	<u>Cost</u>
Natural gas	26¢/therm
Fuel oil	44¢/gallon
Electricity	3.5¢/KW-hr (heating) 4.7¢/KW-hr (cooling)
Annual average degree days:	2,961

<u>Heating Unit</u>	<u>Seasonal Performance Factor*</u>
Natural Gas Furnace	0.60
Oil Burner	0.50
Electric Baseboard Heat	1.00
Heat Pump	2.00

The R factor in the graph is the overall R of the insulation plus sheetrock, sheathing, air film, etc. A tabulation of equivalent R and U values is found on the graph to aid in converting the two units. To calculate seasonal heating costs for other locations, multiply the Atlanta seasonal cost by local fuel cost and heating cost multiplier found in Appendix II, and divide by the Atlanta fuel cost.

*From: "NAHB Thermal Performance Guidelines For One And Two Family Dwellings"

Heating Cost Per Season vs R Factor & U Value (For Atlanta)



This graph can be used to check the payback period for adding insulation. First find the difference in annual heating cost for standard and extra insulation thickness. This is the annual savings. Next divide the extra installed cost per square foot by the annual savings. The result is the payback period in years.

Heating cost can also be found using a calculator and the following equations:

Electric Resistance	\$ per	season	per	sq	foot	=	$0.728 \div R$
Oil Burner	"	"	"	"	"	=	$0.447 \div R$
Electric Heat Pumps	"	"	"	"	"	=	$0.364 \div R$
Natural Gas	"	"	"	"	"	=	$0.308 \div R$

The above equations can be used with "U" rather than "R". Simply multiply by U rather than dividing by R.

It should be noted that the graph is for heating only. A similar graph for air conditioning cannot be constructed due to the large and variable heat gain from windows.

APPENDIX II

HEATING AND COOLING COST MULTIPLIERS FOR OTHER CITIES.

Data for annual cost and savings on the 1200, 1600, and 2200 house plans can be estimated for cities throughout Georgia by use of the following multiplication factors.

City	Heating Cost Multiplier	Cooling Cost Multiplier
Albany	.61	1.62
Athens	.96	1.08
Atlanta	<u>1.00</u>	<u>1.00</u>
Augusta	.82	1.26
Columbus	.77	1.35
Dalton	1.08	.98
Macon	.72	1.44
Rome	1.08	1.02
Savannah	.63	1.46

These multipliers are based on 30 year average heating and cooling degree data from the National Weather Service.

The following example shows how to estimate annual cost and savings for the city of Augusta for house plan 1200. Cost data is taken from the table entitled "Annual Heating and Cooling Cost and Consumption"

For Augusta use .82 heating cost multiplier, 1.26 cooling multiplier.

<u>Standard</u>	<u>Energy Conserving</u>
Heating \$420 x .82 = \$344	\$130 x .82 = \$107
Cooling \$145 x 1.26 = <u>\$183</u>	\$70 x 1.26 = <u>\$ 88</u>
Total, Heating and Cooling Cost \$527	\$195

The total heating and cooling costs of \$527 for the standard plan and \$195 for the energy conserving plan are approximate values for Augusta. An exact estimate would also need to consider design temperature ratios.

Cost of fuel may vary from Atlanta. See Appendix I for Atlanta fuel cost; multiply by local fuel cost divided by Atlanta fuel cost.

Cost for fuel oil and propane are not included in the comparative house plans. Use the following factors:

Cost/Gal	Fuel Oil	LP Gas
40¢	1.06	1.59
45¢	1.46	1.79
50¢	1.62	1.98
55¢	1.78	2.18
60¢	1.93	2.38

Multiply the heating cost data for natural gas by the above factors to find fuel oil or LP gas cost after using heating cost multiplier.

APPENDIX III

COST DATA FOR ENERGY CONSERVING HOUSE PLANS

Item	<u>Extra Cost over Standard Construction</u>		
	1200 Plan	1600 Plan	2200 Plan
Storm Windows	\$ 200	\$ 240	\$ 420
Floor Insulation	44	195	139
Attic Insulation	72	97	68
Wall Sheathing-Foam	109	120	200
Wall Insulation-Fiberglass	20	22	36
Insulated Doors-Reg.	105	70	70
Insulated Doors-French	—	75	75
Ridge and Soffit Vents	89	112	61
Sill Sealer	10	12	10
Caulk Pipe, Wireholes and Soleplate	120	160	220
Set Back Thermostat	85	85	—
EER 9.0 A/C	150	200	—
TOTAL	\$1,004	\$1,388	\$1,299

APPENDIX IV

DEFINITION OF KEY TERMS

BTU (British thermal unit) - a unit of heat to express the amount of heat. The amount of heat required to raise the temperature of one pound of water one degree Fahrenheit. One kilowatt of electricity converted to heat in a resistor produces 3414 BTUs per hour.

BTUH (BTU per hour) - a rate of heat transfer. A structure loses heat at the rate of so many BTUH. Heating equipment must produce heat at an equal or greater BTUH rate to maintain temperature in the structure.

"R" FACTOR - Thermal resistance to heat flow of material of specified thickness. The "U" Factor for a building section equals 1 divided by the sum of resistances of materials used in the construction of a square foot of the building section.

"U" FACTOR - thermal transmittance. Heat loss through 1 sq. ft. of building section with a temperature difference of 1 degree Fahrenheit.

HEATING LOAD - the rate of heat transfer from a structure. Heat loss of windows, doors, walls, ceiling, floor and infiltration are added together to determine the heat loss of a structure.

INFILTRATION - outside air which enters a structure through cracks or door openings.

AMBIENT TEMPERATURE - the air surrounding an object

EER - a ratio calculated by dividing the cooling capacity in BTUH by the power input in watts at any given set of rating conditions, expressed in BTUH per watt.

HUMIDITY - the ratio of the amount of water vapor actually present in the air to the greatest amount possible at the same temperature.

TD - the difference between indoor and outdoor design temperature expressed in degrees Fahrenheit.

THERM - a quantity of heat. One therm is 100,000 BTU

KW - a unit of power equal to 3413 BTU's

KWH - the electrical energy consumed by a 1,000 watt load in one hour of operation.

A/C TONS - a 1 ton air conditioner has 12,000 BTUH of cooling capacity.

VAPOR BARRIER - a material which resists the flow of water vapor

COP - (coefficient of performance) a ratio calculated by dividing the total heating capacity provided by the refrigeration system including circulating fan heat, but excluding supplementary resistance heat (BTUH) by the total electrical input (watts) times 3142 (a ratio calculated for both cooling and heating capacities by dividing capacity in watts by power input in watts).

AIR CONDITIONING LOAD - the rate of heat transfer through a structure. Heat gain of windows, doors, walls, ceiling, floor, and infiltration are added together to determine the heat gain of a structure.

SENSIBLE HEAT - a term used in heating and cooling to indicate any portion of heat which changes only the temperature of the substance involved.

LATENT HEAT - a term used to express the energy involved in a change of state.